PRODUCT ENGINEERING

APRIL, 1949

FORMING THE WORLD'S LARGEST SPUN HEAD

IN THIS ISSUE—Head Shapes as Machine Elements + Torque Reversal Effects in Gear Trains + Bearing Creep + Low Temperature Stainless Steels + Hydraulic Boosters

A McGRAW-HILL PUBLICATION

HOW NEW BRITAIN AUTOMATICS

Maintain Operating Accuracy

"The use of nickel alloy steels and irons in the construction of these new machines has resulted in an extremely rigid, powerful machine tool with both initial and permanent accuracy."

NEW BRITAIN MACHINE COMPANY

Output soars . . . and costs drop . . . when automatics maintain accuracy at the high machining speeds permitted by carbide tooling. But . . . only extremely rugged machines can utilize carbide-tipped tools to maximum advantage because they demand rigid, heavy mountings . . . steady feed at constant high speeds . . . no backlash in cams, followers, rollers, shafts or gears.

And these essentials can be assured by massive design incorporating nickel alloyed steels and irons, as exemplified by the new automatic screw machine, shown above, built by New Britain-Gridley Division, New Britain Machine Company, New Britain, Conn.

Some 244 parts are produced from nickel-molybdenum steels, heat treated to provide an optimum combination of strength, toughness and wear resistance. In addition, vital cast components are produced in nickel-molybdenum iron to assure good wear resistance and machinability.

For dependable, trouble-free performance specify nickel alloys in *your* equipment. We invite inquiries regarding specific applications.

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Over the years, International Nickel has accumulated a fund of useful information on the properties, treatment, fabrication and performance of engineering alloy steels, stainless steels, cast irons, brasses, bronzes, nickel silver, cupro-nickel and other alloys containing nickel. This information is yours for the asking. Write for "List A" of available publications.

THE INTERNATIONAL NICKEL COMPANY, INC.

67 WALL STREET
NEW YORK 5, N.Y.

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FRONT COVER—A stainless steel clad head, 20 ft. 4 in. in diameter, about to be removed from the world's largest spinning machine for reheating between forming operations. Kodachrome courtesy of Lukens Steel Co.

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In the home, too . . .

MALLORY ELKONITE* CONTACTS

Mean a Flip of a Switch
Instead of a Hunt for a Fuse

Out go the lights! A "short"! Once it meant a mean trip to the cellar fuse box—often to find that the right fuse was missing. Now, in more and more homes, it simply means a flick of a nearby switch.

Equipped with Mallory-developed Elkonite Contacts, circuit interrupters have brought this new convenience. This same Elkonite is the contact material used in circuit breakers of giant power plants. Elkonite that served one of the world's largest test circuit breakers—at Grand Coulee—which interrupted 7½ *million kva*, more than twice the kva load of any breaker now in service.

With the protection of thousands of homes—and giant power stations—at stake, the circuit breaker contact has a huge responsibility. And Mallory Elkonite is equal to it. Made by a special process, Elkonite features hardness, conductivity, resistance to wear and impact, erosion by arcing, and sticking. It is one of many types of Mallory contact materials that meet wide applications.

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For all kinds of contact materials and service, you can't beat Mallory as a dependable, experienced source.

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Highlights

In this summary of technical developments, space restrictions do not allow giving complete details. Further information relating to any item can be obtained by writing to the Editor of Product Engineering.

METALLIC MATERIALS

DELTAMAX, a magnetic orientated 50 percent nickel-iron alloy, has a rectangular hysteresis loop. Coercive force is low and useful range of induction is in excess of 26 kilogausses. Applications include contact convertors and magnetic amplifiers. Comes in the form of sealed cores.

SINGLE-CRYSTAL METALLIC SHEETS ½ in. square and 10 mils thick are being produced in a special furnace. A sample of pure metal is heated in a near-perfect vacuum to a point just above melting and then cooled slowly and evenly.

MODIFIED MONEL ALLOYS containing from 93 to 99 percent nickel and various alloying metals were displayed at the recent IRE show. One special alloy is intended for use in cable shielding, although it is finding applications in the structural members of vacuum tubes.

HARD-SURFACING POWDER, "Surfaceweld A", produces a thin chromium case on metal parts. Applied with a carbon electrode, single layer has a Rockwell C hardness of 54-61; multiple layers are slightly harder.

COST REDUCTION is going to be the No. 1 design consideration in the coming year. To accomplish this, many of the inherent possibilities in the applications of die-castings, precision castings, die-forgings, stainless steel and brazed assemblies will have to be explored. The June issue of Product Engineering will be devoted to detailed studies that demonstrate the progress already made in products such as pumps and variable-speed drives.

COLD FINISHED steel studs are replacing higher-cost Cr-Mo and Cr-Ni-Mo alloy parts in truck axles and transmissions, as well as farm tractors. No heat-treatment after machining is necessary. Rods, hexagons and squares are available in SAE grades 1137 to 1144 (free cutting) and 1025 to 1050 (plain carbon).

ALUMINUM FOIL laminated on cotton is the new style in fire-fighting garb. Tests conducted by several of the government services reveal that a man can remain within 2 feet of a 1,500 F flame for 25 minutes.

NONMETALLIC MATERIALS

COLORED NYLON MOLDING POWDER is now on tap -- 13 different tints are in production, four more are on the way. Colors, added during formulation, are permanent and unaffected by molding temperatures. No sacrifices in the properties of the natural material are made.

FIRE-RETARDANT PAINT, called Flame-Seal, withstands 2,000 F torch flame for 30 min. Coating is moisture-proof and said to be non-chipping, non-cracking and non-peeling. No special mixing is needed; just brush or spray it on.

LAMINATED RESIN-IMPREGNATED wood rollers are rapidly replacing the standard wooden parts in fabric mills. The old type was good for about two years - some of the new units have four years to their credit and are still going strong.

"SCOTCH" TAPE strong enough to compete with metal strapping and rope is finding increased use for heavy duty packaging. Designated No. 320, the tape has a tensile strength of 180 lb per inch of width and is 13-15 mils thick. A single turn is sufficient to secure conduits, rods, rolls, sheets, coils, fittings, and tubing.

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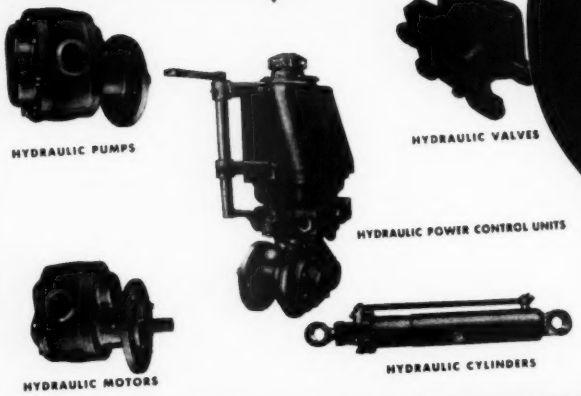
LaPLANT CHOATE
HYDRAULIC PRODUCTS



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LaPLANT-CHOATE MANUFACTURING CO., INC.
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LaPLANT CHOATE

DIAMONDS measuring 1/8 in. across each face can do a better job counting gamma radiations than the Geiger-Müller tube. Clamped between brass electrodes charged at 1,000 v d-c, gem can count more pulses in a given period and do it indefinitely at no added initial cost.

ELECTRIC WINDOWS made of Fiberglas cloth over a polyester honycomb core forms part of the rudder skin assembly of airplanes carrying "internal" antennae. Special sections permit passage of communications signals into and out of the plane.

PROCESSES

NICKEL COATING on steel by chemical rather than electrochemical methods. Corrosion resisting coat is deposited from a hot nickel-chloride-boric acid solution upon immersion of the steel part. Plating is then heat-treated to increase compactness and adherence. Diffusion of the nickel into the base material during heat treatment at 600 C for 30 min makes a good paint base.

INJECTION PROCESS permits molding of plastics around tape, wire or chain. Intricate, decorative designs are possible as colors and shapes can be repeated, skipped or alternated. Max length of each plastic element is 1¼ in.

STRENGTH AND DURABILITY are added to shafts and cranks in a toughening process based on the controlled use of so-called "trapped" or residual stresses in metal. Old-time swordsmiths and blacksmiths unknowingly used this process in which air causes the outer layer of a part to solidfy faster than the core. When cooled, the core contracts and compresses the outer layer. Finished product is therefore under compressive stress in the outer surface and under tension inside.

HYDRO-FINISH, a modified form of impact blasting, utilizes liquid-suspended abrasives as fine as 5,000 mesh for cleaning machined parts and holding tolerances as close as 0.0001 in. By varying particle size and hardness, air pressure and liquid-abrasive ratio, an infinite number of finishes is possible.

POLYETHYLENE FILMS cast continuously in varying thicknesses do not require a solvent of any kind. The semi-fluid resin is transferred from a highly polished carrier to paper, fabric, foil or other base. Speed of production is dependent solely on proper regulation of the required heats and chills.

STATOR LAMINATIONS for appliance motors are being welded to sheet metal positioning plates thus doing away with the customary through bolts. Magnetic performance is equal to that of the bolted assembly and an 11 percent saving in material is made. Watch for the detailed story in the "Cost Reduction" issue of P.E. in June.

ELECTRICAL AND MECHANICAL PARTS

WOVEN STAINLESS STEEL WIRE specially formed into a small cylinder is the heart of a new shock and vibration mount. System is inherently damped, drift-resistant and unaffected by temperatures ranging from -60 to +200 C. What's more, the load per mount can be as low as 15 lb or as high as 90 lb without changing the characteristics of the mount.

THE "ELECTRON WAVE TUBE" recently developed emulates nature in achieving energy amplifications of over 10,000,000 times. Streams of electrons of different velocities are injected into an evacuated metal tube. Electrical repulsion between electrons causes radio signals applied to the tube to be amplified as electrons drift through space.

TINY MICROPHONE smaller in diameter than a dime and weighing less than 1/4 oz, has greater sound output than that of conventional instruments. Device functions throughout the audio spectrum and loudness range.

HYDRAULIC MOTORS for variable speed controls on industrial equipment such as machine tools are expected to give serious competition to electronic variable speed drives -- so says one lead-

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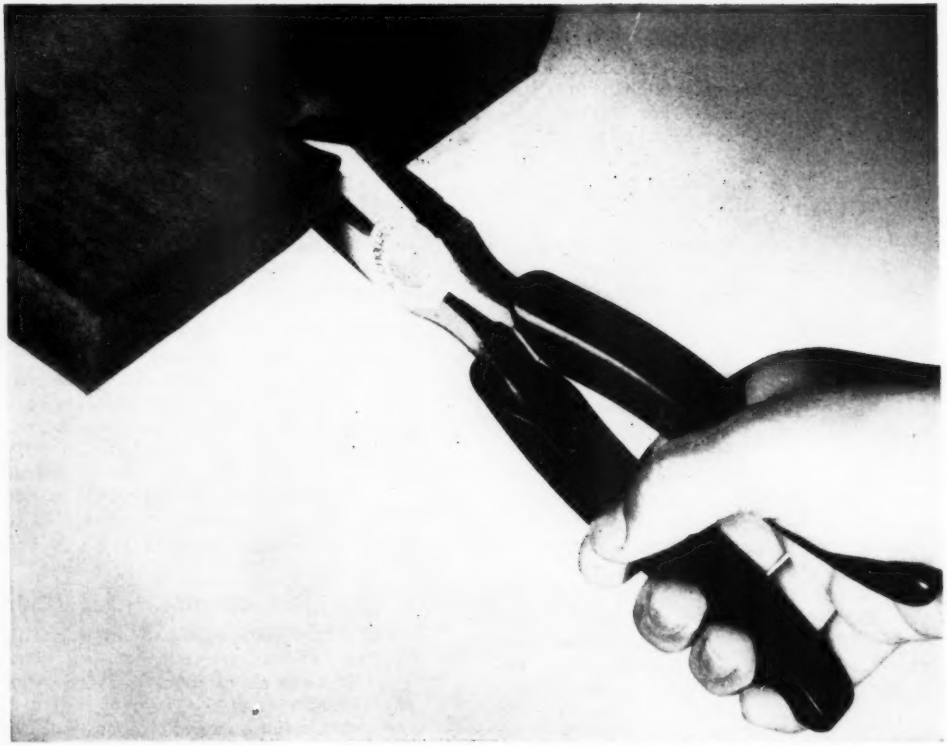

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For more information, write or ask your supplier to write B. F. Goodrich Chemical Company, Dept. HJ-4, Rose Building, Cleveland 15, Ohio.

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ing manufacturer. Technically, these motors can be classified as hydrostatic torque (or speed) converters -- first cousins to the hydrodynamic torque converters now used in cars and buses.

A 56 x 16 AIRPLANE TIRE, designed for use on jet bombers, is well fortified for high landing and take-off speeds. Tire contains 1½ miles of bead wire and 113 miles of nylon thread, uses 240 lb of air pressure and will carry a load of 60,000 lb per tire or 2/3 the gross weight of a Pullman car.

TESTING

TWIST DETECTOR shows changes in weight as small as one part in 100,000. Elastic drift meter has a cross-arm bolted to the free end of a 25-in. anchored shaft. Changes in weight on the cross-arm open sensitive electrical contacts. Shaft twist is determined by the distance a gage must move to reclose the contacts.

AN ELECTRON DIFFRACTION INSTRUMENT for studying layers of metal less than a quarter-millionth of an inch thick may spur the development of longer-wearing metals for aircraft engines. A beam of electrons is shot through the metallic sheet. The electron image on a fluorescent screen or photographic film permits study of surface conditions.

COLOR COMPUTOR continuously integrates light and material reflectance values over the complete visible spectrum. Called the Tristimulus Integrator, instrument indicates whether a given color matches another, and, if not, calculates the difference between them. Data are fed from a recording spectrophotometer to a ball and disk computor. Calculations to an accuracy of 0.05 percent are completed in two-and-one-half minutes.

X-RAY THICKNESS GAGE is sensitive to variations of five-millionths of an inch occurring in rapidly moving sheet metal, glass, plastics, paper and other strip materials. No contact is made between instrument and the strip under test. An unbalance of two X-ray beam intensities --one constant, the other changing continuously--energizes the instrument.

WEAR QUALITIES of synthetic paints and varnishes can be determined from vibration produced by high-frequency sound waves rather than by abrasive wheels. The vibration excitation needed to shake a sample coating off a duraluminum cylinder cap is proportional to the life of the film under normal wear.

LONGITUDINAL FISSURES in wires of diameters up to 0.003 in. are spotted under a microscope--a slow process. Now there's an easy way--load the wire to about 90 percent of known breaking load and pull it over a sloping knife edge while bent at 90 deg. After bending, wrap wire on a revolving slanted spindle. Sound wire breaks at 80-90 percent of normal load, fissured sections snap at values as low as 15 percent.

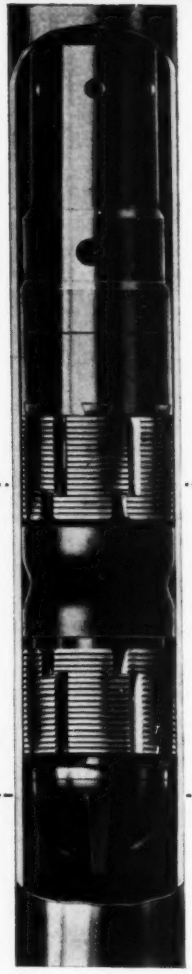
PRODUCTS

LIQUID OXYGEN and a special converter are the secret of a 229-lb saving in weight and a 44 percent increase in oxygen supply in high altitude breathing equipment. Complete outfit occupies 6 cu ft, a fifth of the space required for gas systems.

TWO HORSEPOWER aircooled gasoline engine weighs only 23 lb and occupies just over one cubic foot of space. It's a two-cylinder opposed unit that can be run either vertically or horizontally.

A MACHINE for making color inlays on plastic products is capable of handling either small or large parts. The "Stamp-O-Matic" can imprint as many as three colors in one feeding at speeds up to sixty finished pieces per minute.

PISTON CLASSIFIER measures bores of automobile engine blocks and signals for automatic delivery of proper sized piston for each cylinder. Device measures each bore at four places and marks it in one of eight sizes--all in a few seconds. Another machine measures 500 pistons per hour, computes the size of bore each will fit and delivers each in the proper sequence as called for by the first machine.



Drillable Bridging Plug made by the Lane-Wells Company, Los Angeles, California, whose successful setting depends on the shear strength of two small pins of Revere Herculoy. These plugs vary from 3⅜" to 5⅜" in length.

These are the two small pins, made of Revere Herculoy to standard shear strengths, thus assuring proper setting of the Tripvet plug. Pins are shown actual size.

Dependability protected through standardized-strength Herculoy

● Here is a case in which the successful operation of a large and somewhat complicated device depends upon one of its smallest and least expensive parts. The parts are two pins of Revere Herculoy. The device is a plug employed to seal off an oil well at any desired depth, to prevent taking oil or water from lower strata.

Proper setting of this plug within the well depends on those two small pins. They must shear at exactly the right load, imposed by a special setting tool. If the pins should shear too easily, the plug might not be securely set in the well and might fall to the bottom; if the pins were too tough, the plug might not set at all. From the material standpoint, successful operation of a device costing as much as $310.00 depends on the uniform shear strength of a few cents' worth of rod.

It was to assure that uniformity that the Revere Technical Advisory Service was called into action. Studies were made of the needs, tolerances specified, and means devised to assure meeting them. The specifications when finally drawn up were rather unusual, and their fulfillment is another demonstration of Revere's ability to turn out special orders when absolutely necessary. Incidentally, Lane-Wells Company, maker of the Drillable Bridging Plug, also uses Revere phosphor bronze, strip brass, Herculoy rod and free cutting brass rod for other parts.

Before you place your next order for copper and copper alloys, get in touch with the nearest Revere office. And remember, if you are having any difficulties in the employment of copper and brass mill products, the Revere Technical Advisory Service will gladly collaborate with you.

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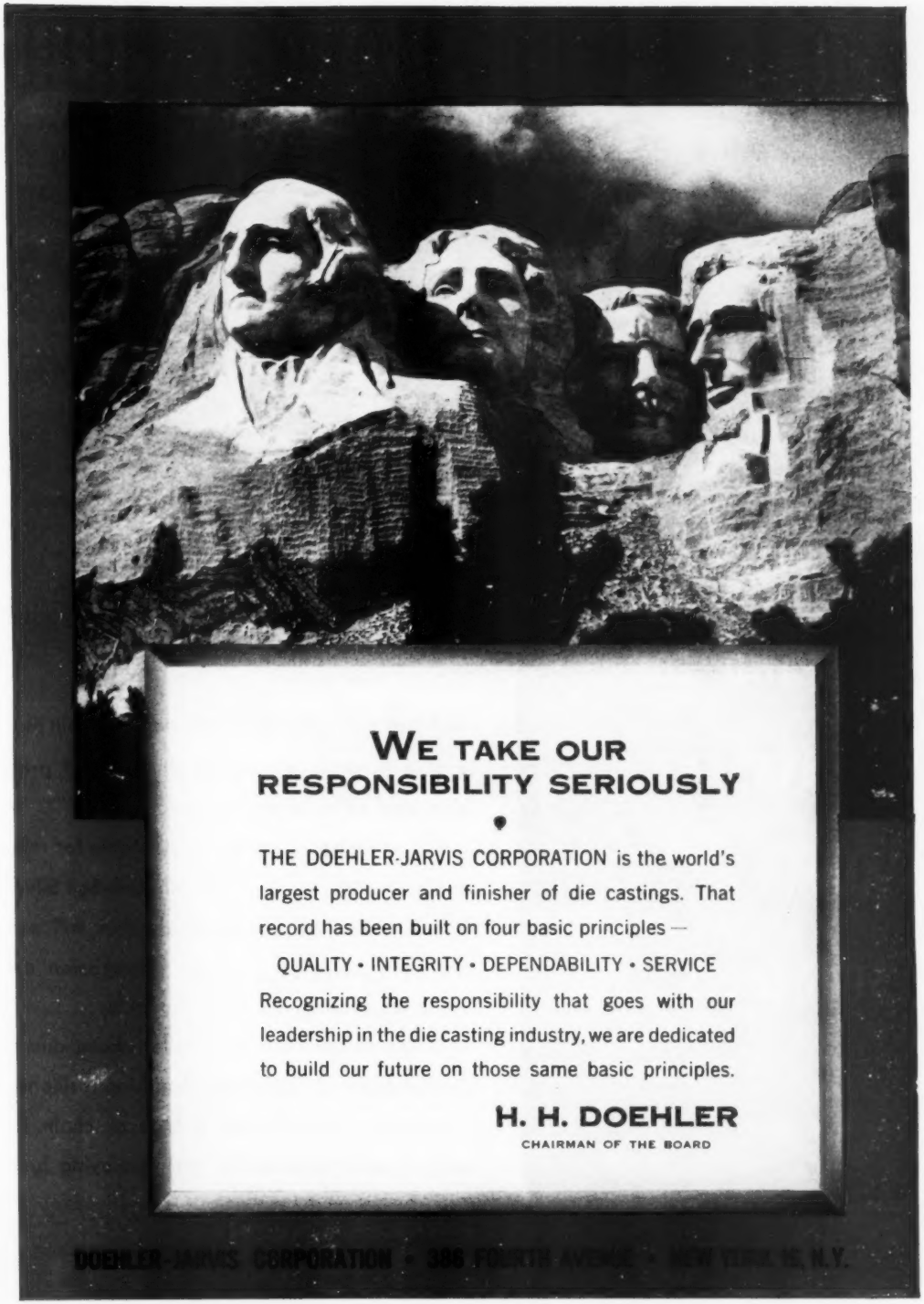
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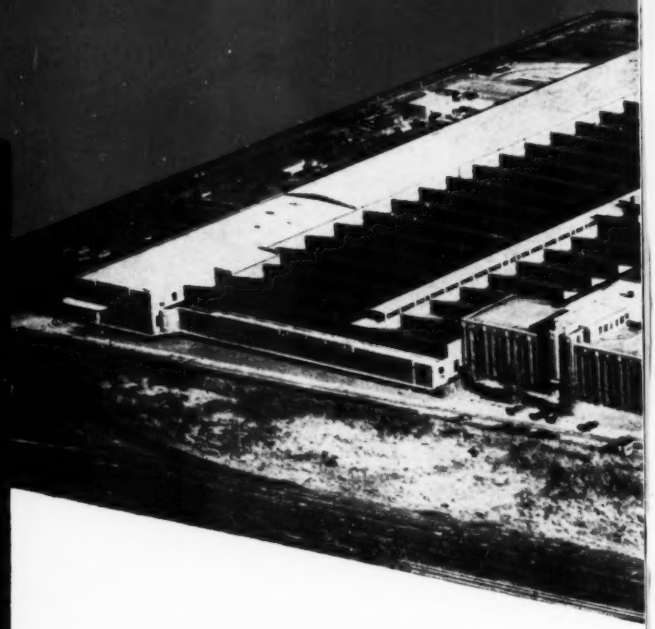

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. . . . . .

Link-Belt's addition to its Indianapolis chain plant makes possible immediate shipment of precision steel roller chain and sprockets.

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Silverlink precision steel roller chain, due to special features, has shock absorbing resilience.

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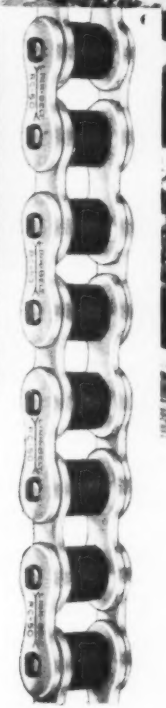

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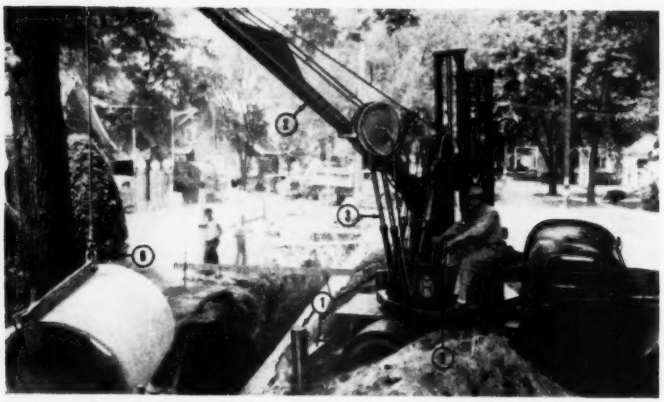
**IMPORTANT: NEW, TENTATIVE INDUSTRY-WIDE HYDRAULIC STANDARDS HELP TO FOCUS ATTENTION ON BENEFITS FROM HIGHER PRESSURES —Blackhawk specializes in engineering and manufacturing hydraulic components and systems with pressure ranges from 1,000 p.s.i. up to 10,000 p.s.i. This range (according to "Hydraulic Standards for Industrial Equipment" compiled recently by the Joint Industry Conference) overlaps the "Medium High" pressure class (above 500 to and including 1,200 p.s.i.) and the "High" pressure class (1,200 to 3,000 p.s.i.) and the "Extra High" pressure class (above 3,000 p.s.i.). These new industry titles help Blackhawk customers identify the superior pressure ranges of their hydraulic systems.*

THESE HIGHER PRESSURES CREATE UNUSUAL BENEFITS for users of Blackhawk components. Blackhawk PUMPS and VALVES (because of higher pressures) are strikingly compact and RAMS have smaller diameters. The entire hydraulic system gains from (1) less weight, (2) easier installation, (3) less friction, (4) improved appearance, (5) simplicity, (6) lower costs and (7) easier service.

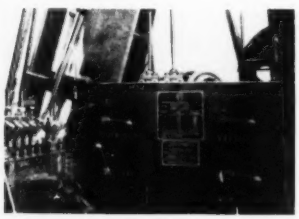
Over 5000 Parts Eliminated by Blackhawk Pumps and Valves



EVERY POUND IS "LIVE WEIGHT" because compact Blackhawk Hydraulics replace customary mechanical devices on large, low-pressure hydraulic systems. Blackhawk valves and pumps activate the following operations: (1) control outriggers to hold crane in position; (2) extend or contract boom; (3) lower or raise boom; (4) lower and lift hoist line; (5) rotate boom; (6) when clamshell is used, jaws are hydraulically controlled.

Unique Development in Crane-Excavator Field is All-Hydraulic

Blackhawk high-pressure hydraulic components, including multiple control valves and compact heavy-duty power-driven pumps, eliminate an estimated 5,000 parts (gears, shafts, clutches, drums, brakes, etc.).



THESE COMPACT BLACKHAWK "VALVBANKS", which can be safely managed by even an inexperienced operator, control functions of the all-hydraulic crane-excavator.

BLACKHAWK HYDRAULIC EQUIPPED

AN EMBLEM REPRESENTING DEPENDABILITY THROUGHOUT INDUSTRY

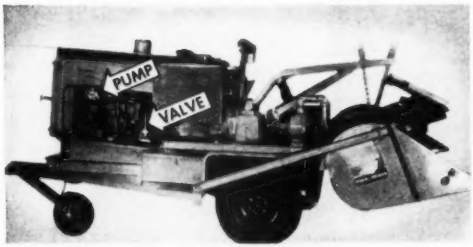
PIONEER SPECIALISTS IN HIGH-PRESSURE HYDRAULICS FOR 25 YEARS

Blackhawk Pumps, Rams and Valves Answer the Need for Simple, Economical Controls On This Pulverizer

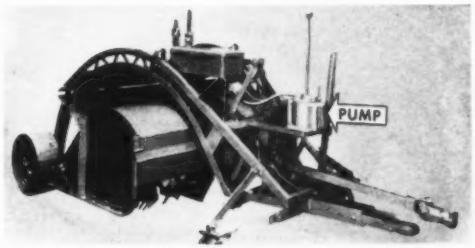
Manufacturer Benefits by Having One Dependable Source For Many Hydraulic Components

This manufacturer had the problem of finding economical, compact means to supply precision depth control for his pulverizer. Blackhawk's integrated hydraulic controls offered the ideal answer because they are compact, simple and low in cost. Subsequent adaptations of the pulverizer, as pictured below, utilized many other components from the long line of standard Blackhawk hydraulic devices.

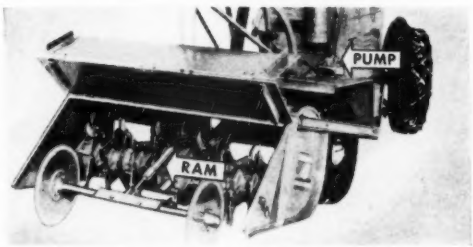
The great range of Blackhawk hydraulic devices enables the equipment manufacturer to depend on Blackhawk as its key source for hydraulics—creating savings in development, procurement and other functions.



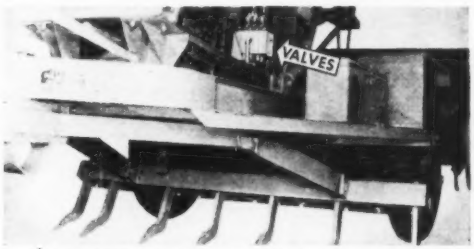
1 A BLACKHAWK POWER-DRIVEN PUMP AND CONTROL VALVE are on this Auxiliary Spray Bar and Pump which closely synchronize the addition of liquids to "mix."



2 A MASS-PRODUCED, STANDARD BLACKHAWK HAND PUMP, plus a ram, are incorporated on the pulverizer when adapted to airport-levelling operations.



3 A BLACKHAWK HYDRAULIC RAM forces tines into sheet ice when the pulverizer is converted to an ice rotor.



4 UNDER CONTROL of Blackhawk "Valvbanks" — the pulverizer's scarifier attachment utilizes these compact, multiple control valves.

Sensible costs, practical design are no accident at Blackhawk...
they are born from proven Engineering and Manufacturing policies

Only with Blackhawk can you draw from a quarter-century of experience in engineering and manufacturing of high-pressure hydraulic equipment! And you get more than the invaluable benefits of high-pressures . . . you also benefit from exclusive refinements built into Blackhawk components. Comparatively, Blackhawk's PISTON-TYPE pumps furnish greater volumetric efficiencies in the higher pressure ranges—and Blackhawk offers a host of other exclusives in ram and valve designs.

"Specials" or "Standards" . . . A great many manufacturers depend on Blackhawk for specially-designed hydraulics to fit individual needs. Blackhawk has the engineering service for this work. But Blackhawk also can furnish components that are of standard design, continuously produced and sold in quantities for installation on products of other manufacturers. These products and integrated services are catalogued in profusely illustrated literature. Ask for bulletins on "High-Pressure Hydraulics," then let us counsel in confidence.

Blackhawk Mfg. Co., 5300 W. Rogers St., Milwaukee 1, Wis.

BLACKHAWK®

COMPLETE HYDRAULIC SYSTEMS—PUMPS (HAND AND POWER-OPERATED), VALVES AND RAMS.

F.E. Myers assures

SAYS MR. C. GINN, Vice President and General Manager of the F. E. Myers & Bro. Co., one of the leading water pump manufacturers: "We regard the use of standard motors for pump and water system service as an important advantage to our customers. Motor exchange plans, made possible by the use of standard motors, enable the user to get his pump back in operation with a minimum of delay. Any interruption of water supply is serious and, if extended, may be disastrous, especially to farmers. The use of standard motors and consequent ease of replacement and service is a big talking point for our products."

More for your money with

STANDARD G-E Fractional-Horsepower MOTORS

Unit-Bearing Fan

Washing Machine

Oil Burner

Machine Tool

Gas Pump

Hermetic Refrigeration

customer satisfaction WITH GENERAL ELECTRIC STANDARDIZED Fractional Horsepower MOTORS

Here's the motor that F. E. Myers & Bro. Co. says helps make customer service a strong selling tool—the G-E General Purpose Capacitor-Start Motor. It is widely used on water-pumping systems, commercial refrigeration and air conditioning compressors, industrial air compressors, material handling equipment, motorized tools, commercial laundry equipment . . . wherever high starting torque, long life, and minimum servicing are required.

The General-Purpose (Type KC) has an open (dripproof) enclosure, 40 C rise, and a solid base. It is immediately available in ratings from $\frac{1}{6}$ to 1 hp; 3450 to 1140 rpm; constant speed; single-phase, 60, 50, or 25 cycles. For more details, call or write your nearest G-E sales office. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

THEY'RE QUIET . . . AND COMPACT . . . AND RUGGED

Sleeve bearings are bored to a mirror-like finish for long-lived, quiet operation. Starting is snappy, yet quiet.

Sound design and the use of modern insulating materials has packed a lot of motor into a little space.

The sturdy end shields, rigidly support the bearings and the frame itself is all-steel, rolled and machined.

GENERAL ELECTRIC

Belted Fan

Coal Stoker

Jet Pump

Shaft-Mounted Fan

Sump Pump

General Purpose

How many of these packing installations can you identify?

All of them depend on Houghton Packings

Every reader will recognize the conventional machine designs pictured above, but some of the hydraulic devices may be difficult to identify in these small reproductions.

We'd like to offer a prize to those who can correctly name all of these types of hydraulic mechanisms—but we'll resist the temptation. If you'd like a complete list of the installations pictured above, write us.

Of course, we should rather have you write for details or recommendations on some hydraulic packing job on which you are now working. You no doubt know that Houghton, pioneer in packings, supplies all types and styles of hydraulic and pneumatic packings, including both leather and synthetic rubber—fabricated, homogenous and "O" rings. We're neutral, will suggest the best type of packing for the job. Won't you write us? E. F. Houghton & Co., Philadelphia 33 and all principal cities.

HOUGHTON'S
VIM LEATHER and VIX-SYN PACKINGS

COUNT

Mechanically...

Strokes, revolutions, pieces, volumes, lengths . . . or other units of performance and production . . . can be counted by Veeder-Root Mechanical Counters like this new General-Purpose No. 1260. This direct-reading, streamlined counter counts up to 1,000,000 . . . then resets (unless you want to reset it sooner) with one turn of knob. And it's *compact,* so it can be ***built into*** most machines and products, to add utility and marketability.

Magnetically...

To report machine output direct from plant to office . . . or to count units of a size or weight that makes them tough to count mechanically . . . count on these new Veeder-Root Reset Magnetic Counters, No. 1205 for AC, No. 1248 for DC. Easy to install on regular light circuit . . . widely used with "electric eye." And they may be grouped on panels, at any distance from the machines they report on.

Manually...

To count people, poles, shrubs, blood-corpuscles, cars, ticket-buyers . . . or anything that can't be counted mechanically or magnetically . . . count on this No. 1023 Hand Tally that fits both hand and pocket. To count one, press thumb-lever once. When count is complete, turn reset knob, start over from zero. Ends errors from memory-count and pencil tallies.

These are only 3 of the scores of types of Veeder-Root Standard and Special Counters. Most likely you, too, can count on Veeder-Root, to your profit. Write.

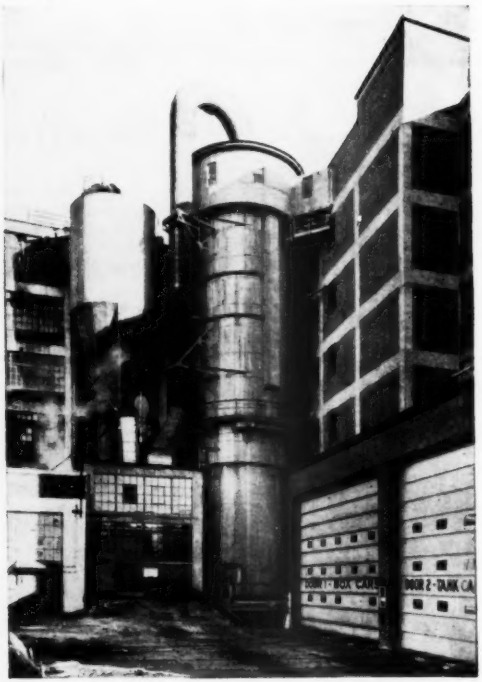
ON VEEDER-ROOT

VEEDER-ROOT INCORPORATED
HARTFORD 2, CONNECTICUT
In Canada: Veeder-Root of Canada, Ltd., 955 St. James St., Montreal 3.
In Great Britain: Veeder-Root Ltd., Kilspindie Rd., Dundee, Scotland

Quality Control in Producing

includes INCONEL-CLAD STEEL PROTECTION

For all maintenance cleaning. Write Colgate for free working sample—enough to make 40 gallons of cleaning solution. (In Canada: Toronto. In U. S.: Jersey City, N. J.)



Most imposing equipment at the Toronto, Ontario, plant of Colgate-Palmolive-Peet Co., Ltd., is this 150-foot Inconel-Clad Steel spray tower in which VEL is solidified.

Inconel is inert in the presence of materials employed in the production of VEL, the soapless cleanser. Inconel surfaces protect the purity of the product, and the equipment is not harmed by corrosion. That's why Colgate-Palmolive-Peet Company, Ltd., uses Inconel-Clad Steel processing equipment in their Toronto, Ontario, plant.

In this Lukens Clad Steel, the Inconel cladding (usually 10% or 20% of total plate thickness) is inseparably bonded to steel backing plate. Thus, the equipment provides protection equivalent to this *solid* corrosion-resistant metal and yet its use shows *clad* steel economies.

If your processes need the protection offered by nickel, stainless steel, Inconel or Monel, you can gain similar economies through the use of Lukens Nickel-Clad, Stainless-Clad, Inconel-Clad and Monel-Clad Steels. Lukens produces plates up to 178 inches wide, or to over 3 inches thick. The extra smooth, sodium hydride finish makes equipment extra easy to clean.

For further data, write for Bulletins 255 and 338. Lukens Steel Company, 405 Lukens Building, Coatesville, Pennsylvania.

CLAD METAL STEEL

LUKENS

Nickel-Clad Stainless-Clad
Inconel-Clad Monel-Clad
STEELS

SOLID METAL ADVANTAGES WITH CLAD STEEL ECONOMY

• • SPEED SCRAP TO THE MILLS TO MAKE MORE STEEL • •

How TIMKEN® bearings keep a shaper in shape

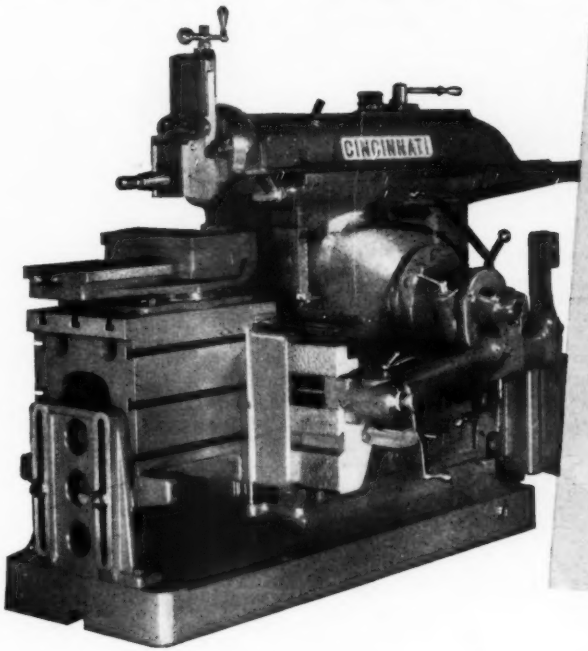
THE outstanding features of this Cincinnati 24" Universal Shaper include built-in rapid traverse to the table feed, completely enclosed transmission, and location of controls within easy reach of the normal operating position. And, of course, Timken® bearings are included on the pulley shaft, power rapid traverse shaft, and on the cross-feed screws to assure maximum precision and long, trouble-free service.

Timken tapered roller bearings keep shafts in rigid alignment under the heaviest loads. Lubrication is simplified and power loss is reduced to a minimum.

Due to the tapered construction of Timken bearings, they carry any combination of radial and thrust loads. Manufactured to extreme precision and finished to incredible smoothness, Timken roller bearings make friction practically negligible. Full line contact between rolls and races permit maximum load carrying capacity. And since they're made of the finest steel ever developed for tapered roller bearings—Timken fine alloy steel—they last the life of the machine.

With a background of almost fifty years of bearing research and development, Timken tapered roller bearings are first choice throughout all industry. No other bearing can bring you *all* the advantages you get with Timken bearings. Look for the trade-mark "Timken" on every bearing you use. The Timken Roller Bearing Company, Canton 6, O. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.



This **CINCINNATI** *24" universal shaper relies on Timken bearings on pulley shaft, power rapid traverse shaft and cross feed screws for precision and trouble-free operation.*

NEW TIMKEN BEARING CUTS RUN-OUT IN HALF!

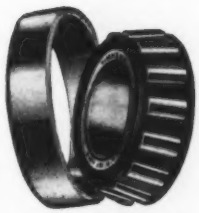
Until now, the Timken "Zero" bearing has been the last word in bearing accuracy. Now Timken offers industry the "Double-Zero" bearing—*twice as accurate* as the "Zero"! Maximum run-out of the new "Double-Zero" bearing is only 75 millionths of an inch—*half* the 150 millionths run-out of the "Zero" bearing.

What an opportunity for manufacturers of machines where extreme accuracy is essential! Available in standard single row types, up to 10" O.D. Write for further information.

TIMKEN

TRADE-MARK REG. U.S. PAT. OFF.

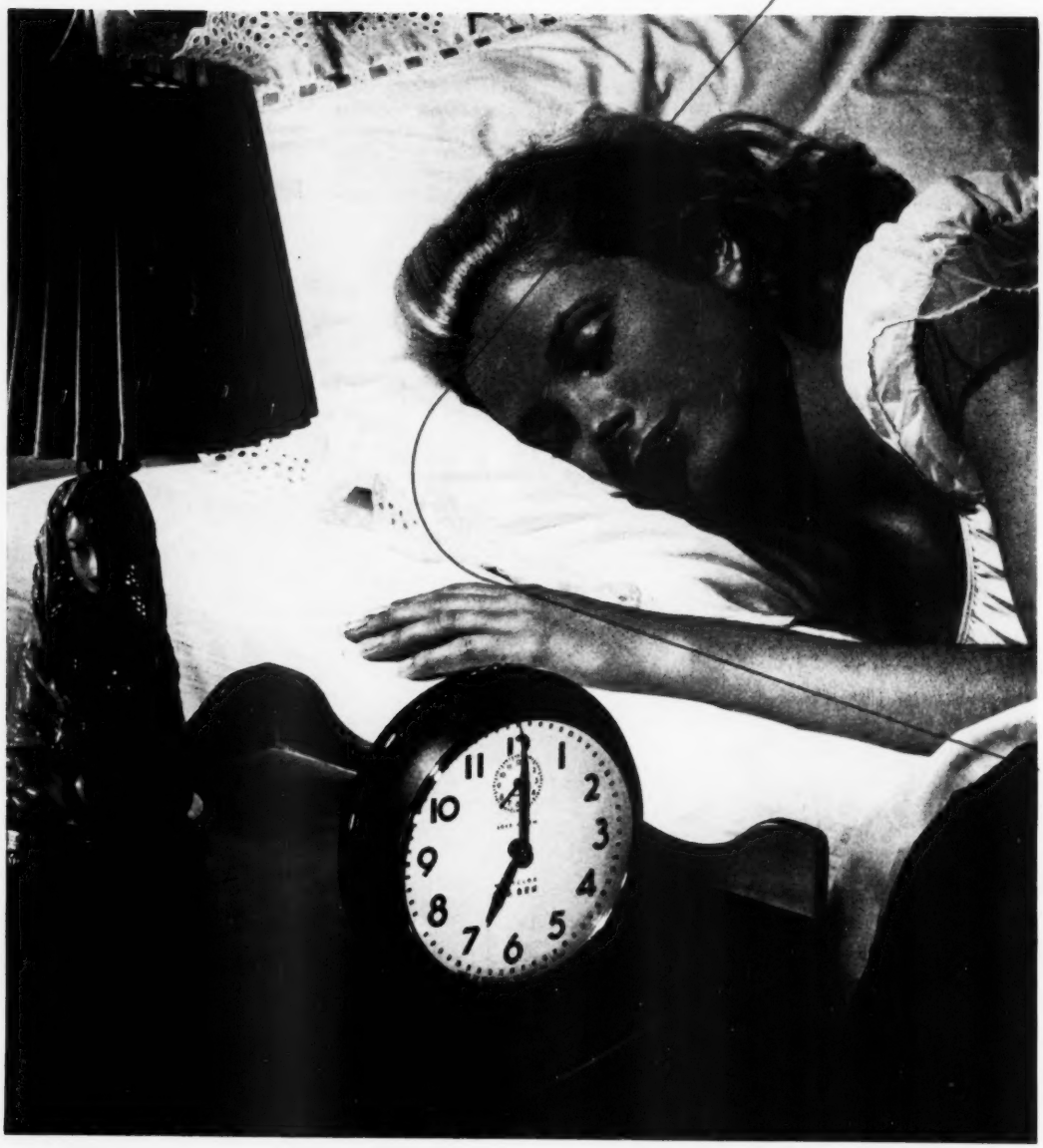
TAPERED ROLLER BEARINGS



NOT JUST A BALL ○ NOT JUST A ROLLER ⊂⊃ THE TIMKEN TAPERED ROLLER ⊂⊃ BEARING TAKES RADIAL ◎ AND THRUST ⊣◎⊢ LOADS OR ANY COMBINATION ⊣◎⊢

Helping to give BIG

that gets millions



BEN the powerful "voice" of families up on time!

It's a mighty important job, rousing millions of families each morning!

The faithful gong that starts the day for most of America is made from steel we supply to Westclox. So are many other parts. Pillars—shafts—body cases—movement holders—plates—even tiny barrel hooks so small that 20,000 of them would scarcely fill a thimble are made of our Cold Rolled Strip Steel, Steel Wire or Rods. In ALL these parts, unfailing uniformity and close tolerance precision are imperative. For upon them depends the accuracy of the timepieces in which they are used.

When the 200 millionth Big Ben rolled off the production line several months ago, it marked a milestone in our long association with Westclox. It illustrated our ability to provide year after year, the "tailor-made" parts of strip, wire or rod to meet unusually severe specifications.

This case is typical of the work we are doing for numerous other manufacturers.

If you are using strip steel, wire or rods in your product, we are at your service to help you make it easier to produce—more efficient in performance—and easier to sell.

AMERICAN STEEL & WIRE COMPANY, GENERAL OFFICES: CLEVELAND, OHIO

COLUMBIA STEEL COMPANY, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS

TENNESSEE COAL, IRON & RAILROAD COMPANY, BIRMINGHAM, SOUTHERN DISTRIBUTORS

UNITED STATES STEEL EXPORT COMPANY, NEW YORK

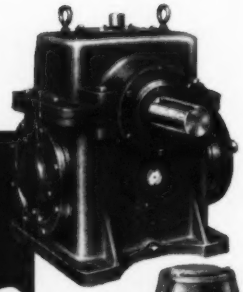
AMERSTRIP

COLD ROLLED STRIP

USS

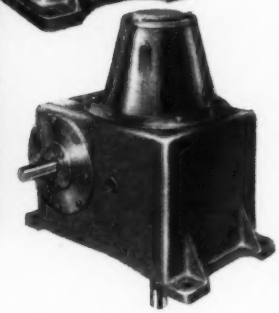
UNITED STATES STEEL

Foote Bros. Hypower Enclosed Worm Gear Drives assure economy in original cost and economy in operation. They bring a new compactness in design plus greatly increased thermal capacity. Available in vertical and horizontal types.



Foote Bros. Straight Line Enclosed Gear Drives will shortly be introduced. These compact units may be used with any standard motor. Ratios range from 5 to 240 to 1.

looking for drives?



THEN LOOK TO FOOTE BROS.

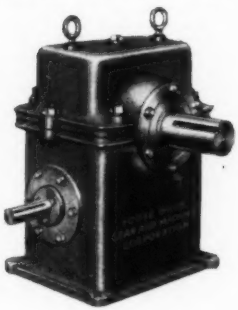
Foote Bros. Hytop Enclosed Worm Gear Drives provide wider low-speed bearing span. Ideal for installation where low-speed shaft extensions cannot be supported by pilot or guide bearings at the end of shaft. Available in both Hygrade and Hypower types.

If you require enclosed gear drives, the Foote Bros. line offers a wide variety of types, sizes and ratios to meet any need.

Nearly a century of engineering and manufacturing experience is back of Foote Bros. Drives. Two large plants contain the newest in gear generating equipment—new techniques in manufacture—better metallurgical control of materials—improved manufacturing methods—all assure you superior enclosed gear drives.

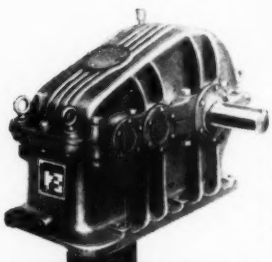
Mail the coupon for information.

Foote Bros. Hygrade Enclosed Worm Gear Drives have been newly engineered and now offer the maximum in rugged dependability. Specially designed for heavy-duty applications. Available in both horizontal and vertical types.



AVAILABLE FROM-STOCK

A new policy of distribution now makes Foote Bros. Enclosed Worm Gear Drives available from stock. A range of sizes and ratios is offered to meet many industrial applications.



Foote Bros. Maxi-Power Helical Gear Drives are available in single, double and triple reductions. A newly engineered line that represents the last word in modern power transmission equipment.

FOOTE BROS.

Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION
Dept. W, 4545 S. Western Blvd., Chicago 9, Illinois

Foote Bros. Gear and Machine Corporation
Dept. W., 4545 S. Western Blvd., Chicago 9, Ill.
Gentlemen: Please send me information on drives checked below:

- ☐ Hypower Enclosed Worm Gear Drives
- ☐ Hygrade Enclosed Worm Gear Drives
- ☐ Maxi-Power Enclosed Helical Gear Drives
- ☐ Straight Line Enclosed Gear Drives

Name .....
Company .....
Address .....
City ..... *State* .....

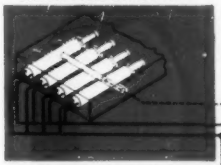
KEROSENE LAMPS IN YOUR DRAFTING ROOM?

CERTAINLY NOT!

And General Electric Calrod* Heaters can solve your surface heating design problems in the same way you light your offices . . . electrically! Yet some designers are still trying to solve surface heating problems with equipment almost as antiquated as the kerosene lamp . . . when it is so easy to apply uniform, easy-to-control, surface heat with G-E Calrod Heaters like this . . .

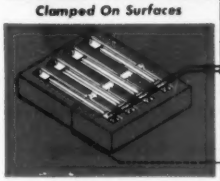
*Reg. U. S. Pat. Off.

Inserted Into Drilled Holes



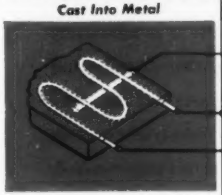
CALROD CARTRIDGE HEATERS Where space is limited, space-saving, fast-heating, cartridge heaters may be inserted into drilled holes or cast into metals. Sheaths of brass, nickel-silver, or chrome-steel in ratings from 30 to 1200 watts; sheath temperatures up to 1200 F.

Clamped On Surfaces

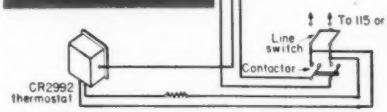


CALROD STRIP HEATERS Clamp easy-to-install strip heaters on surfaces in jig-time. Flat surfaces provide excellent heat conduction. Available in two types: steel-sheathed for temperatures up to 750 F; chrome-sheathed for temperatures up to 1200 F.

Cast Into Metal



CALROD TUBULAR HEATERS Can be bent into any shape, cast into metal, clamped on surfaces, or inserted into drilled holes. Sheathed in steel, nickel-silver, or high-temperature alloys. Ratings from 500 to 7500 watts. Sheath temperatures up to 1500 F.



G-E Thermostat (CR2992) controls Calrod heaters accurately and effectively over a wide range of temperatures up to 750 F.

Typical Surface-Heating Applications with General Electric CALROD Heaters

platens ● pre-shrinking machines ● packaging machines injection molding machines ● cigarette machines ● textile machinery ● bottle capping ● die heating ● embossing food-vending machines ● matrix scorching ● molding presses ● valve warming ● rubber molding machines ● roll heating ● sand drying ● aluminum extrusion ● paper machinery ● vulcanizing machinery ● tire recapping equipment

There is a G-E Calrod heater for virtually every surface-heating requirement and every surface. For best results, consult your G-E Heating Specialist before you design.

For valuable surface-heating ideas and application data, get your FREE COPY of the new publication, "HEATING SURFACES," GEA-5097. Just clip and mail the coupon.

MAKE THINGS "HOT" For Your Customers with G-E CALROD HEATERS

MAIL COUPON NOW

Apparatus Department, Sect. D720-1
General Electric Company, Schenectady 5, N. Y.

Please send me a copy of your new, idea-packed publication, "HEATING SURFACES," GEA-5097.

Name.....

Company.....

Address.....

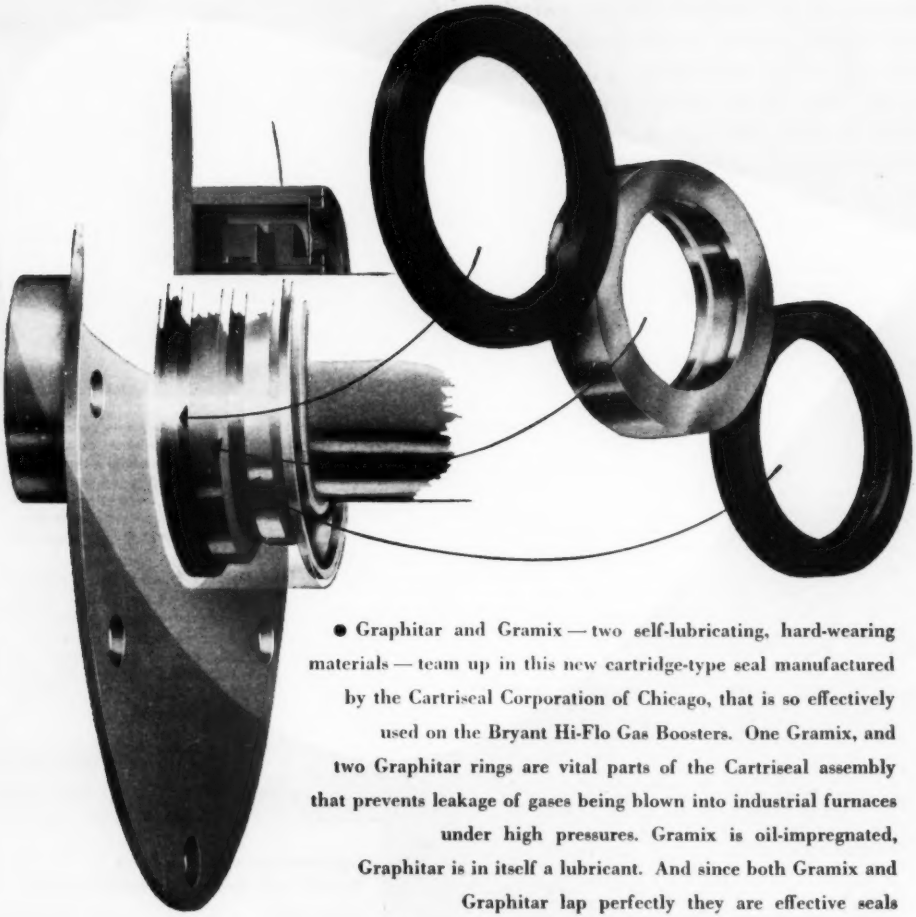
City..... **State**.....

GENERAL ELECTRIC

GRAPHITAR AND GRAMIX

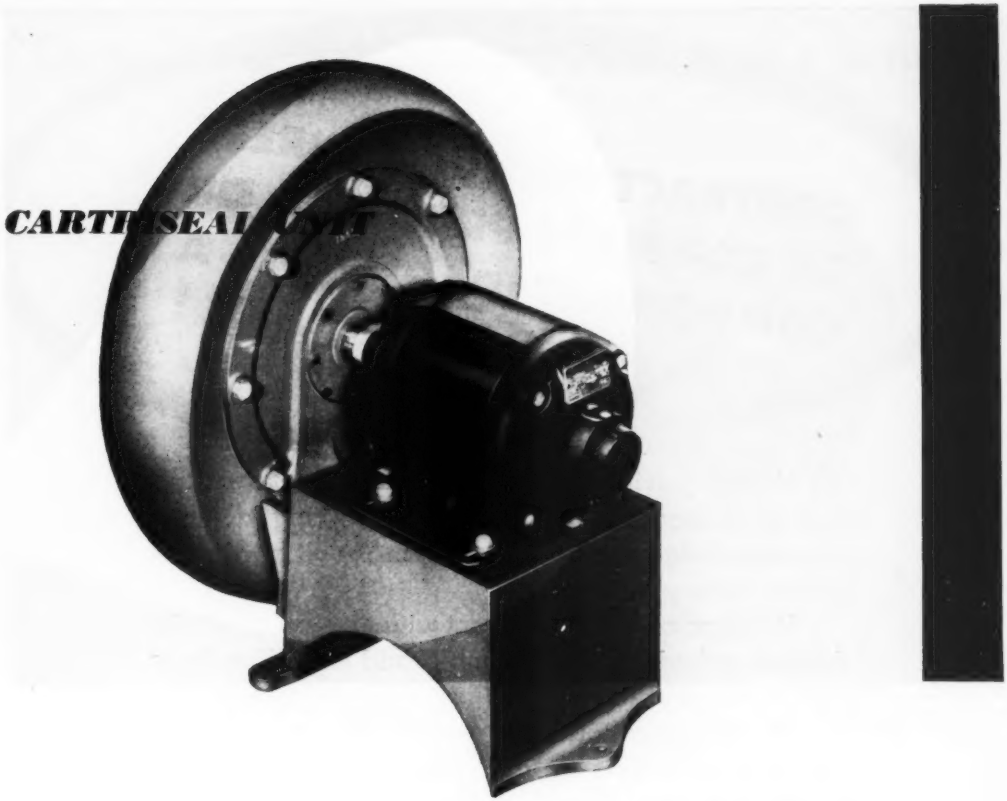
(CARBON-GRAPHITE)

form leak-proof seal on efficient new



● Graphitar and Gramix — two self-lubricating, hard-wearing materials — team up in this new cartridge-type seal manufactured by the Cartriseal Corporation of Chicago, that is so effectively used on the Bryant Hi-Flo Gas Boosters. One Gramix, and two Graphitar rings are vital parts of the Cartriseal assembly that prevents leakage of gases being blown into industrial furnaces under high pressures. Gramix is oil-impregnated, Graphitar is in itself a lubricant. And since both Gramix and Graphitar lap perfectly they are effective seals regardless of shaft speed and constant daily service.

THE UNITED STATES GRAPHITE COMPANY



GRAPHITAR AND GRAMIX are two unique materials that have found hundreds of uses in industry. Graphitar — a carbon-graphite material — is strong, extremely lightweight, self-lubricating, chemically inert and practically unaffected by temperature extremes. Graphitar can be finish ground to tolerances as close as .0005" in small sizes. Gramix parts are pressed powdered metal, oil-impregnated to require no additional lubrication, and finished with such precision that further machining is not required. Graphitar and Gramix may help solve a production problem for you. Send us your prints and we will be glad to make recommendations without obligation.

DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

CONTRACT MANUFACTURERS OF COMPLETE PRODUCTS OR COMPONENT PARTS ON A FIRM BASIS!

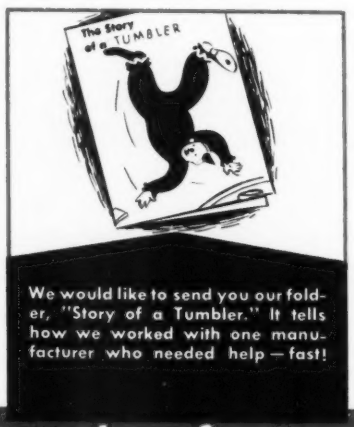
WE ARE privileged to serve many manufacturers and sales agencies who need metal working facilities. Our knowledge of metal working make us a valuable source of supply.

Working on a firm contract with you, on a definite delivery schedule, we assemble and ship directly to you or your customer.

"In the Hub of Industry" we offer an abundance of skilled labor and a plentiful supply of materials. From a shipping standpoint, too, we are ideally situated.

Our facilities are as follows: Sheet Metal Fabricating —20 gauge to ¼" plate, machine shop, metal spinning and finishing to 14 gauge.

Write, wire or phone.



We would like to send you our folder, "Story of a Tumbler." It tells how we worked with one manufacturer who needed help — fast!

IN THE HUB OF INDUSTRY

Cincinnati Metalcrafts Inc.

Division B

5000 Brotherton Road Cincinnati 9, Ohio

Phone: REdwood 2214

"Commercial" Ball Bearing Data...#1 of a Series

BALL BEARINGS MADE TO METRIC DIMENSIONS

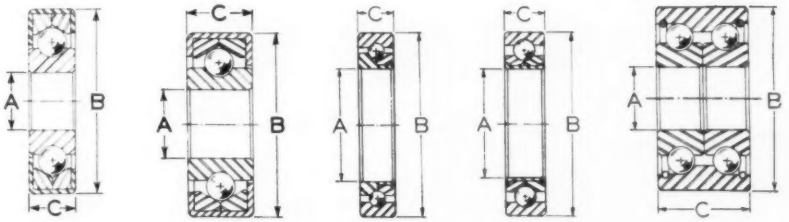
Among the many types of Schatz "Commercial" Ball Bearings now furnished in metric sizes are:

Type "A" *Unground* Ball Bearings

Type "AA" *Precise* Single Row Ball Bearings

Types "KR" and "KRS" Ball Bearing Rollers with Hardened Tread

Type "ARTDR" *Unground* Radial-Thrust Double Row Ball Bearings



Use these Schatz "Commercials" wherever speed and load factors permit to replace costly precision bearings in metric sizes.

Unless otherwise specified races are carburized, high-grade, low-carbon steel, hardened and tempered...high quality balls in all bearings...close bore tolerance of +.001", —.000".

SEND FOR NEW CATALOG You'll find detailed drawings and specifications of all Schatz Ball Bearings in our *new* Catalog No. 11. Study the load capacity tables in this factual book. Chances are you'll see where low initial cost of Schatz "Commercials" can save you real money in volume applications—with no sacrifice in operating efficiency. And where standard type "Commercials" aren't adaptable to your needs, Schatz makes a variety of special designs and types that can't be duplicated from any other source.

You'll want this factual book in your files. Write today, put your problem up to Schatz.

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REPRESENTATIVES LOCATED AT
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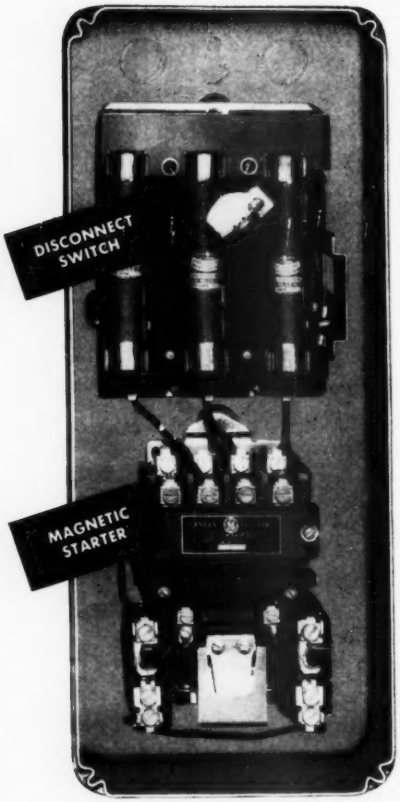
SCHATZ
"Commercial"
BALL BEARINGS

Designer's

ALL YOU NEED to control and protect a motor



IN ONE COMPACT UNIT

ALL-NEW COMBINATION STARTER

All new all the way through! That's the General Electric full-voltage combination a-c motor starter, designed and built for reliable operation, easy maintenance, and long life. A compact, easy-to-mount unit, it combines contactor and its overload relays with disconnect switch and fuses. You get both motor overload ***and*** short-circuit protection!

Cuts installation time Starter and disconnect switch are wired together to be installed as one unit. No extra time or money need be spent on interconnections.

Saves space This one unit takes up less space than separately mounted devices. Its streamlined case means improved machine appearance.

Increases personnel safety New rotary-action disconnect switch makes it impossible to open the cover without opening the circuit. Switch handle and cover can both be padlocked to insure complete protection of personnel.

Made in NEMA sizes 0, 1, 2, and 3 for a-c motors up to 50 hp. Get the full story in Bulletin GEA-5156.

GENERAL ELECTRIC

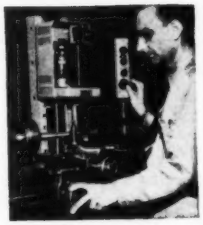
Digest GE PRODUCT HIGHLIGHTS

MEASURES THROUGH THICK OR THIN!

To make sure coatings or linings on production parts are not so thin as to be insufficient, nor so thick as to be wasteful, use a General Electric thickness gage. It quickly, easily measures any non-magnetic material on magnetic iron or steel without marking the finished surface. Simply place the gage head against one side of the coated surface, and an instrument indicates the thickness. Three types available cover a range from 0.00005 to 0.750 inch. Shown is Type A, measuring copper plating thickness on electronic tube parts. See Bulletin GEC-319.

GIVES LOW-COST SPEED ADJUSTMENT!

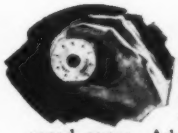
Here's the abridged edition of General Electric's Thy-mo-trol drive—the low-cost Type H1. Utilizing a simplified half-wave electronic circuit, it provides stepless speed adjustment for constant-torque loads over a 20 to 1 speed range from 1725 to 86 rpm. Where close speed regulation and full torque at low speeds are required—but not all the refinements of conventional Thy-mo-trol—the H1 offers an ideal drive at a lower price. Ratings up through $\frac{1}{2}$ hp are available. See Bulletin GEA-5179.



COVERS 90 TESTING DEVICES!

Want a quick round-up of data on specialized testing and measuring devices? This comprehensive, illustrated booklet reviews more than 90 modern General Electric equipments for that purpose. Included are weights, dimensions, and prices, plus references to individual publications containing more detailed information. Convenient grouping under eleven "use" headings lets you locate specific items of interest quickly and easily. See Bulletin GEA-639.

Dial Service for Motor Speeds



Just turn the dial on this General Electric Type ACA adjustable-speed induction motor for quick speed changes, infinitely adjustable over a 3 to 1, 6 to 1, or 20 to 1 speed range. Add a 10-foot flexible cable (for the smaller motor ratings) and you can still dial your speeds. With a pilot motor instead, you can dial from *any* distance.

Compact and self-contained, the ACA is only slightly longer than a constant-speed motor of comparable rating. Standardized NEMA dimensions are used to avoid any new mounting problems. Ratings from 3 to 75 hp are available in Tri-Clad open (dripproof) construction. See Bulletin GEA-4883.

General Electric Company, Section C668-73
Apparatus Department, Schenectady 5, N. Y.
Please send me the following bulletins:

- ( ) **GEA-639—Testing and measuring equipment catalog**
- ( ) **GEA-4883—ACA adjustable-speed motors**
- ( ) **GEA-5156—Combination starters**
- ( ) **GEA-5179—Type H1 Thy-mo-trol drives**
- ( ) **GEC-319—Thickness gages**

CONSULT YOUR McGRAW-HILL ELECTRICAL CATALOG FOR PRODUCT ENGINEERS! You'll find "everything electric" for machinery manufacturers in the General Electric section.

Name .....

Company .....

Street .....

City ..... **State** .....

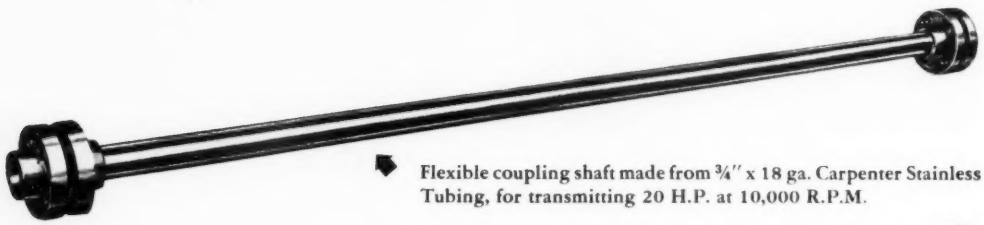
the Designer Wanted "the most perfect concentricity possible"

...and got it by Specifying *Carpenter* STAINLESS TUBING

THE JOB REQUIREMENTS: Fully corrosion-resistant tubes (for weight saving) to act as shafts for flexible couplings. Because shafts transmit heavy loads at speeds from 3,600 to 10,000 R.P.M., the specification called for Stainless Tubing with *the most perfect concentricity possible.*

THE COST FACTOR: Several sizes of tubing were required, and the manufacturer found that in every case Carpenter Stainless Tubing, standard full-finished grade, was ideal for the job. Exceptionally uniform tube walls for this precision job were secured at no extra cost, because the specification called for *Carpenter* Stainless Tubing.

YOUR SAVINGS: The uniform walls of Carpenter Stainless Tubing permit the use of lighter gauges without sacrifice of strength. So it is economical to specify *Carpenter* on your orders—even on jobs where your mechanical requirements do not call for exceptionally uniform tube walls.



Flexible coupling shaft made from ¾" x 18 ga. Carpenter Stainless Tubing, for transmitting 20 H.P. at 10,000 R.P.M.

USEFUL SLIDE CHART OF PHYSICAL PROPERTIES...

A note on your company letterhead will bring you the Carpenter Stainless Tubing Slide Chart. Send for your copy today.

THE CARPENTER STEEL COMPANY
Alloy Tube Division, 121 Springfield Road, Union, N. J.

Carpenter
STAINLESS TUBING
"MORE THAN CORROSION RESISTANCE"

24-HOUR SERVICE **You get definite delivery information within 24 hours when you call your Carpenter Stainless Tubing Distributor.**

NATIONAL OIL SEAL LOGBOOK

PRACTICAL USE OF DUAL-WIPE LEATHER OIL SEALS

Heavy duty mechanisms operating under extreme dust and dirt conditions require two-fold protection of bearings and gears. Operating lubricant or fluids must be retained; harmful abrasives must be excluded from bearings and gear boxes. Many designers are answering this problem by specifying dual-wipe seals.

Typical of such seals are the National 10,000 and 30,000 Series oil seals. The 10,000 series (Fig. 1) is designed for moderate external dust conditions, speeds up to 2,000 F.P.M., and temperatures not exceeding 200°F. The 30,000 Series (Fig. 2) is designed for heavier abrasive conditions, speeds to 15,000 F.P.M., and temperatures not over 200°F.

Auxiliaries of felt are generally recommended for higher shaft speeds than are auxiliaries of leather.

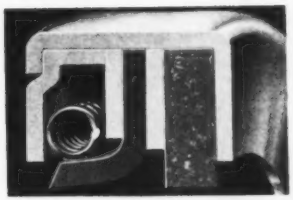


Figure 1

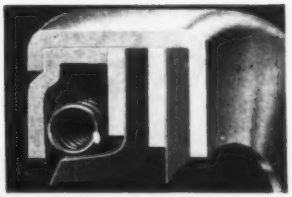
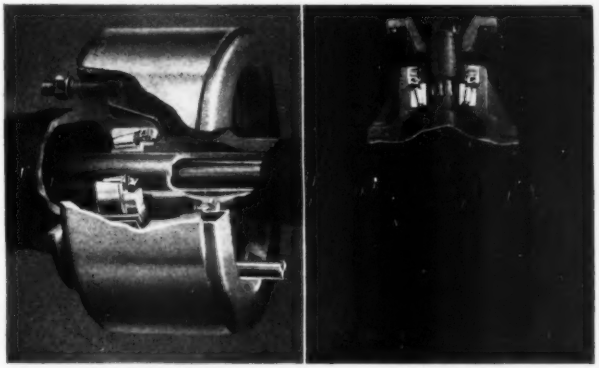


Figure 2



Oil Seal, Rear Wheel — Oil Seal, Pinion

Figure 3

Both seal types are used in the heavy truck pinion and axle in Figure 3.

At the pinion, the problem was to retain lubricant, while excluding fine dust and grit from the mechanisms. A double-wipe seal was indicated, yet it had to be a seal whose exterior member could run "dry," at speeds up to 3,000 RPM. The National 10,000 Series seal answered the problem. Its spring-loaded inner sealing member, running under a pressure head of lube, maintains an effective seal despite high speed. The felt auxiliary effectively keeps out abrasive dust.

At the wheel position, the problem was to retain lubricant within the hub while excluding dirt churned up by the drive wheels. Since speeds were low and the main sealing member could operate under well lubricated conditions, a National 30,000 Series seal proved effective. The spring-loaded main member retains wheel lube, while the dry-running leather flange keeps out abrasives.

Oil seals such as these two National types are generally preferred for applications where speeds are low, such as trucks over $1\frac{1}{2}$ tons, tractors, farm implements and road equipment. When speeds and temperatures beyond those discussed are encountered, synthetic seals will solve the problem. When extreme conditions exist, a special design may be necessary.

For additional information about dual-wipe seals in your product, ask the nearest National Oil Seal Engineer or write direct.

NATIONAL OIL AND FLUID SEALS ®

NATIONAL MOTOR BEARING CO., INC.

General Offices: Redwood City, California
Plants: Redwood City and Los Angeles, California; Van Wert, Ohio

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DALLAS: 30½ Highland Park Village, Justin 8-8453.
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MILWAUKEE: 647 West Virginia St., Marquette 8-8986.
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PHILADELPHIA: 401 North Broad Street, Bell-Walnut 2-6997.
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WEST SPRINGFIELD, MASS.: 1025 Elm Street, Springfield 2-1881.
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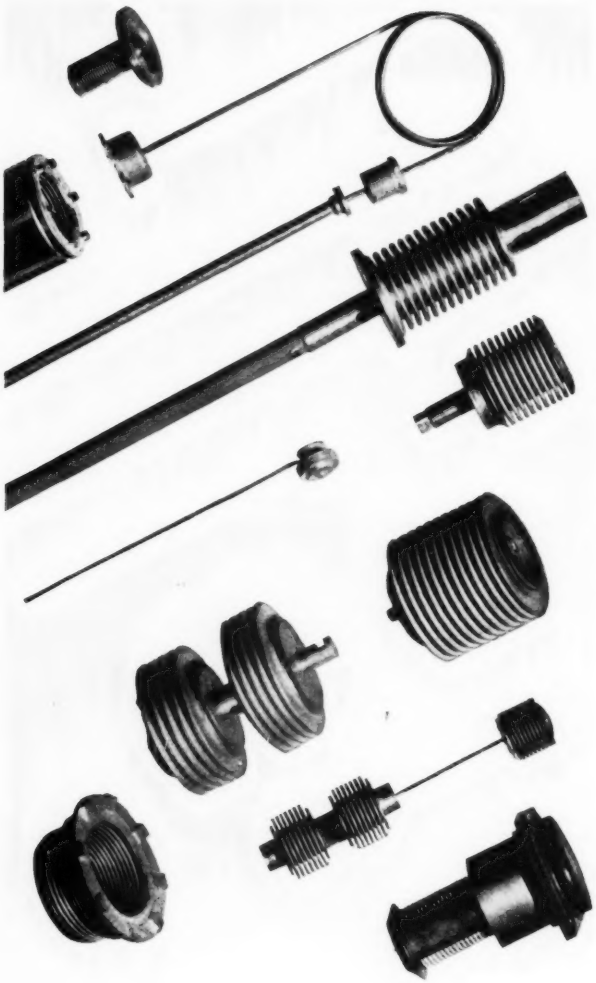
IDEAS

with profitable futures —for your products!



● If accurate control of temperatures or pressures is a design problem for you—check first with Fulton Sylphon or Bridgeport Thermostat. We specialize in producing bellows assemblies and bellows devices to solve such problems in practically all industries—have been doing it successfully for 45 years.

We may have a "ready-made" design that will fit your present product—or your product development plans—perfectly.

Or, if your requirements call for a special type, our engineers will gladly work with you—to develop an idea and *complete* it with a bellows assembly or bellows device specifically for *you*.

You can be assured you'll get finest quality materials and workmanship—prompt service. Production facilities to care for large volume orders.

Write today for any specific information; ask for idea-packed Catalog GP-1200.

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BELLOWS ASSEMBLIES • BELLOWS DEVICES

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in small packages

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WEIRTON

HIGH-CARBON STRIP

COLD-ROLLED SPRING STEEL

Whether you use cold-rolled spring steel for blanking or for forming, there is a Weirton high carbon strip that simplifies production and holds down costs.

Weirton's close control over every phase of manufacture is your assurance of a consistent balance of desirable qualities and properties. You can depend on Weirton High-Carbon Strip for accurate response to heat treatment—uniformity of gage and width—uniform chemical and physical properties—exact constancy of grain structure—controlled decarburization limits. In other words—Weirton High-Carbon Strip makes good products better, helps you make them more economically.

Weirton High-Carbon Strip is obtainable with the desired chemical analysis and for specific heat treating and hardness ranges, in widths up to seven inches.

SPHEROIDIZED
Annealed, soft and ductile—ideal for cold forming operations.

PEARLITIC
Temper-rolled in controlled hardness and strength for blanking.

WEIRTON STEEL CO.

WEIRTON, W. VA., *Sales Offices in Principal Cities*

Division of **NATIONAL STEEL CORPORATION,** *Executive Offices, Pittsburgh, Pennsylvania*

"TEXROPE VARI-PITCH SPEED CHANGERS Boosted Our Output"

"With these clean, compact units we can change speeds without stopping, get in-between speeds we need," says spinning mill foreman.

STEP UP MACHINE OUTPUT in *your* plant with the same variable speed drive that makes spinning mill foreman Ralph Finkboner of Rochelle, Illinois so enthusiastic. Texrope Vari-Pitch Speed Changers give you smooth, accurate speed control at the turn of a crank. You operate your machines at exactly the right speed for highest production. You change to different speeds for different types of material in seconds.

V-belt drive cushions Texrope Vari-Pitch Speed Changers against shock loads. Design is simple, compact, smooth running and easy to keep clean. Capacities range from 1 to 75 HP with stepless speeds up to 3.75 to 1.

The Texrope line also includes Vari-Pitch variable speed drives with stationary or motion control which will solve many variable speed drive problems at low cost. For details on all Texrope drives, the most complete V-belt drive line on the market, see your A-C Authorized Dealer or District Office or write for Bulletin 20B6051G. Also in Sweet's.

Texrope Super-7 V-belts result from the cooperative research of Allis-Chalmers and B. F. Goodrich; and are sold only by A-C dealers and offices. Texrope and Vari-Pitch are Allis-Chalmers trademarks. A-2645

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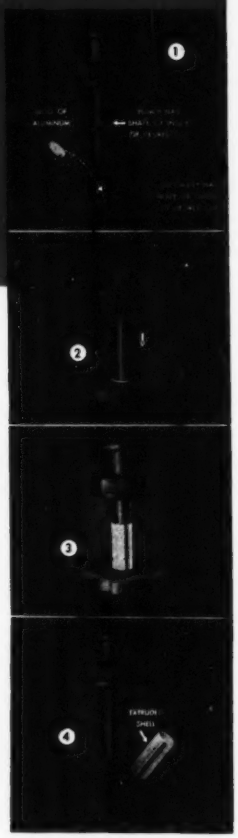
MOTORS — ½ to 25,000 HP and up. Matching Allis-Chalmers Control.

TEXROPE — Belts in all sizes and sections, standard and Vari-Pitch sheaves, speed changers.

PUMPS — Integral motor and coupled types. Sizes and ratings to 2500 GPM.

VARIABLE WALL THICKNESSES

...FOR BEAUTY OR REINFORCEMENT



You Get Them at a Single Stroke of the Punch with the Alcoa Impact Extrusion Process

Designing a housing? Shell? Cylinder? Holding chamber for air or liquid? Forget old-fashioned, time-consuming methods. Faster than the eye can follow, the Alcoa Impact Extrusion Presses will form walls and bottom in one piece; strong, sound, low in cost.

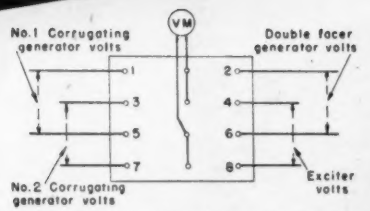
Perhaps you want to add inner ribs for reinforcement, or outside fluting for modern beauty. *They can be formed as your part is formed,* with this amazing process. Walls thick enough to tap for fittings? A heavy bottom, or neck? Form them, too, integral with the part, *in the same split second.*

No designer can afford not to know about the shortcuts made possible by Alcoa Impact Extrusions. Write today for your copy of the booklet shown, or phone your nearest Alcoa sales office for a representative. ALUMINUM COMPANY OF AMERICA, 692 Gulf Building, Pittsburgh 19, Pennsylvania.

ALCOA *Aluminum* **IMPACT EXTRUSIONS**

ALCOA ALUMINUM

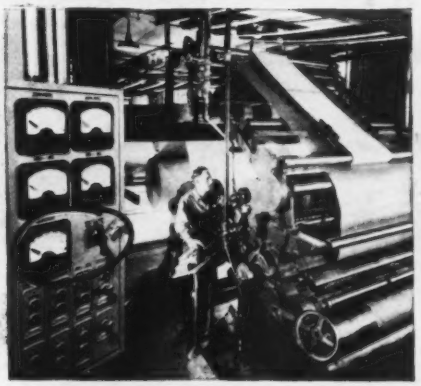
this job... VOLTMETER READINGS ON CORRUGATING MACHINE



Here's the circuit—An SB-1 used as a voltmeter selector switch. One switch accurately and economically takes care of four voltages—using only one meter

Contacts Handle end		Positions				
		4	3	2	1	Off
1 2	1				X	
	2		X			
3 4	3			X		
	4	X				
5 6	5				X	
	6		X			
7 8	7			X		
	8	X				

This contact diagram provided an easy way to specify the exact circuit-sequence combination



Operator's panel of a new combined corrugating and double facing machine. The 4-position SB-1 switch makes possible fast readings of critical voltages

...easily done with the SB-1

Standard parts and the simple basic design of the SB-1 mean longer life and low initial cost to you. There's a *standard* SB-1 for most jobs, and they're ready on six weeks delivery. A variety of attractive switch handles, and watertight, dust-tight, oil-immersed, fabricated metal, or explosion-proof housings are available to fit your particular installation problems. Why not try an SB-1 on your particular control problem? For further details see your G-E sales representative and write for Bulletin GEA-4746. *Apparatus Dept., Section D 856-9, General Electric Company, Schenectady 5, N. Y.*

CONTROL AND TRANSFER SWITCH
Rating up to 20 amp at 600 volts a-c or d-c

GENERAL ELECTRIC

Carpenter Stainless No. 20

NOW

Carpenter Stainless No. 20 Tubing and pipe sizes produced by Alloy Tube Division, The Carpenter Steel Company, Union, New Jersey

Making Stainless More Useful To You . . . and making Stainless cost less for you to use . . . have been the ideas behind Carpenter's research in Stainless. As a result of that research, free-machining Stainless was invented in Carpenter's laboratories. The first bright and ductile Stainless strip was developed by Carpenter men . . . and now "Stainless 20"

to Resist SULPHURIC ACID!

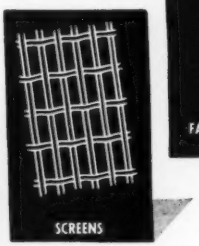
Now a New Stainless Steel Ready to Take on New Jobs...

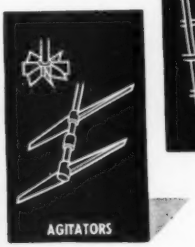
Here is news about a highly corrosion-resistant alloy available for the first time in the forms of bars, wire, strip and tubing.

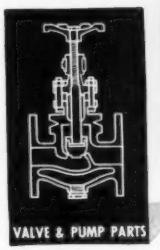
In the past, the alloy has been available only in the cast form, known as Durimet 20. Now that Carpenter has overcome the problem of producing this alloy in the wrought form, its usefulness in solving corrosion control problems has been greatly increased.

There are two general types of applications in which Carpenter Stainless No. 20 can provide new and increased economy. First, in processes where sulphuric acid solutions are present at various temperatures and in various concentrations. And second, in handling other highly corrosive acids and solutions where an extra margin of safety is required, over and above the corrosion resistance provided by other types of Stainless Steel.

Your inquiries and orders for Carpenter Stainless No. 20 will receive prompt attention. If you care to investigate the corrosion resistance of the material under actual operating conditions, we will be glad to work with you on sample orders.







Typical Uses for Carpenter Stainless No. 20

Corrosion Resistance and Physical Properties Data...

These data pages will give you useful information on Carpenter Stainless No. 20 and the jobs it can do. For your copy, just drop us a note on your company letterhead, indicating your title, and ask for the Carpenter Stainless No. 20 data pages. We will be glad to put them in the mail for you.

THE CARPENTER STEEL COMPANY · 117 W. BERN ST., READING, PA.

Export Department: 233 Broadway, New York 7, N. Y. "CARSTEELCO"

Carpenter

STAINLESS NO. 20

Licensed under patents of The Duriron Co., Inc.

Carpenter Stainless No. 20 is available in the forms of bar stock, wire, strip and tubing.

Some of America's most modern automotive drives depend on Hydron Bellows Assemblies for sealing rotating shafts against leakage.
Have you investigated Bellows Assemblies lately?

More and more leading firms are improving the quality of their products by using bellows assemblies to seal shafts or valves against leakage, to control temperature and pressure and to transmit motion. Maybe you, too, should consider bellows assemblies before your designs are too far advanced. Our engineering department will gladly study your sketches and specifications in strict confidence and make a recommendation. This free service does not obligate you in any way. Write: CLIFFORD MANUFACTURING COMPANY, 564 GROVE STREET, WALTHAM 54, MASS. *Division of Standard-Thomson Corporation.* Offices in New York, Detroit, Chicago, Los Angeles.

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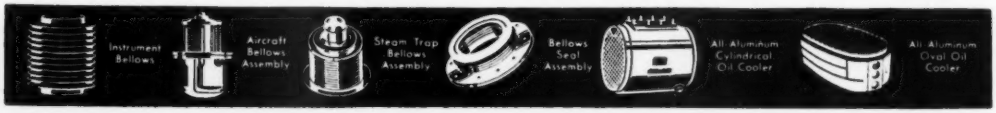
HYDRAULICALLY-FORMED BELLOWS AND BELLOWS ASSEMBLIES

ALL-ALUMINUM OIL COOLERS FOR AIRCRAFT ENGINES

First with the Facts on Hydraulically-Formed Bellows



Build more "SELL" into your product with G-E Components

Wherever there's a choice!

On the counter, where the competition is stacked side by side against it—every product needs the extra push that finally makes it the customer's choice.

Getting the choice—making the most of that last-minute decision—is a cinch for the G-E Flamenol* cord set. The big, bold General Electric tag gets attention fast. The smart, tough cord and molded-on plug tell their own story of reliability.

Why not give your product the edge when the choice is being made? Give it the sales advantage of the General Electric Flamenol cord set. For more information, write to Section Q32-467, Construction Materials Department, General Electric Company, Bridgeport 2, Connecticut.

*Trade-mark Reg. U. S. Pat. Off.

HEATER CORDS are no longer a designer's nightmare. General Electric heater cords are now available with the bright, new "400" plug that's designed to look as new as your plans for tomorrow. It's made of a tough, solid piece of plastic—and you can order from a wide range of sparkling colors. Once you see it, you'll want the new "400" plug on all your heater cords. Let us give you more details.

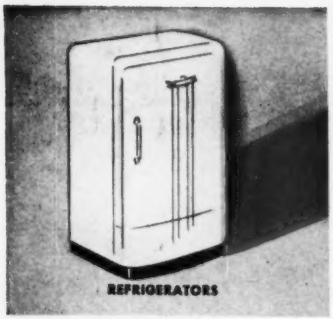
CORD SET ASSEMBLIES—**Even simple circuits—consisting of cord set, switch, and socket—may be costing you more than you think. If rejects are high—if your space is limited—it may pay you to turn this operation over to us. If you are interested, we'll gladly give you an estimate on turning out completed assemblies for you.**

COMPONENTS FOR FLUORESCENTS are also part of the complete General Electric line. Wherever you use fluorescents, be sure they're equipped with General Electric components all the way through. General Electric switches, lampholders, and starters help make a fluorescent fixture a fixture you can count on.

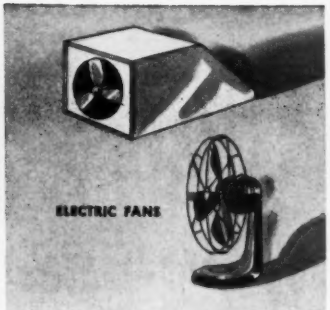
SERVICE TO MANUFACTURERS—If you'd like to know more about General Electric accessory equipment—if you're interested in custom-made components—if you'd like information on our merchandising aids—we'll supply you with the information you need. For information, contact the G-E accessory equipment representative in your area, or write to Section Q32-467, Construction Materials Department, General Electric Company, Bridgeport 2, Conn.

GENERAL ELECTRIC

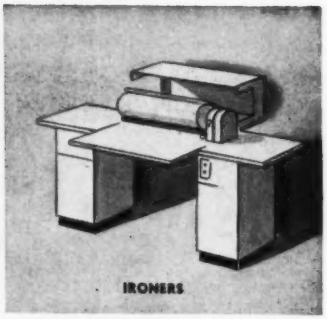
Flamenol CORDS



REFRIGERATORS



ELECTRIC FANS



IRONERS

WASHING MACHINES

OIL BURNERS

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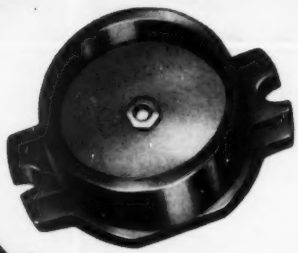
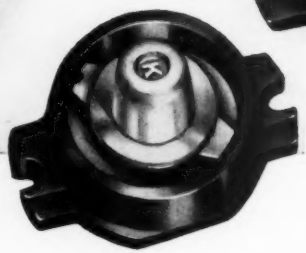
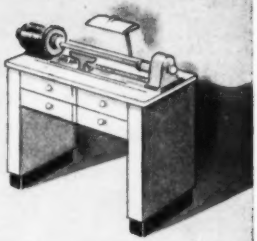




AUTOMATIC RESET

MANUAL RESET



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No matter what the product — machine tools, electric appliances, adding machines, oil burners — you can help build user acceptance by using and specifying motors with built-in Klixon Protectors.

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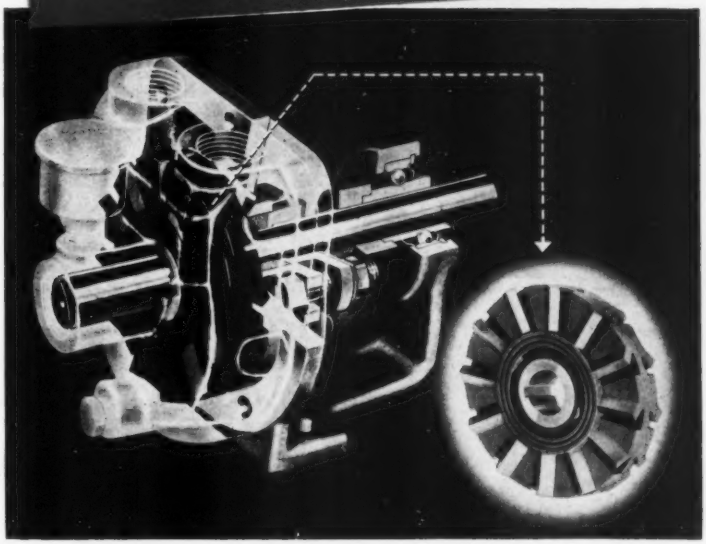

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for example:

The heart of this new pump is a rotor of resilient, wear-resistant NEOPRENE

Constructed to operate at speeds up to 3600 RPM and pressures up to *60 lbs.*, these new universal units are designed to pump both erosive and corrosive liquids. Engineers specified neoprene for the pump's most vital part—its rotor, because of the tremendous strain it must withstand. And neoprene really does the job! Its inherent resistance to the deteriorating influences of *corrosive liquids and fluids contaminated with abrasives* made it excellent for this application. Neoprene's resilience permits the passage to fines, chips, grit and other foreign matter. And its resistance to abrasion, and to permanent distortion despite constant flexing, assures long, trouble-free service.

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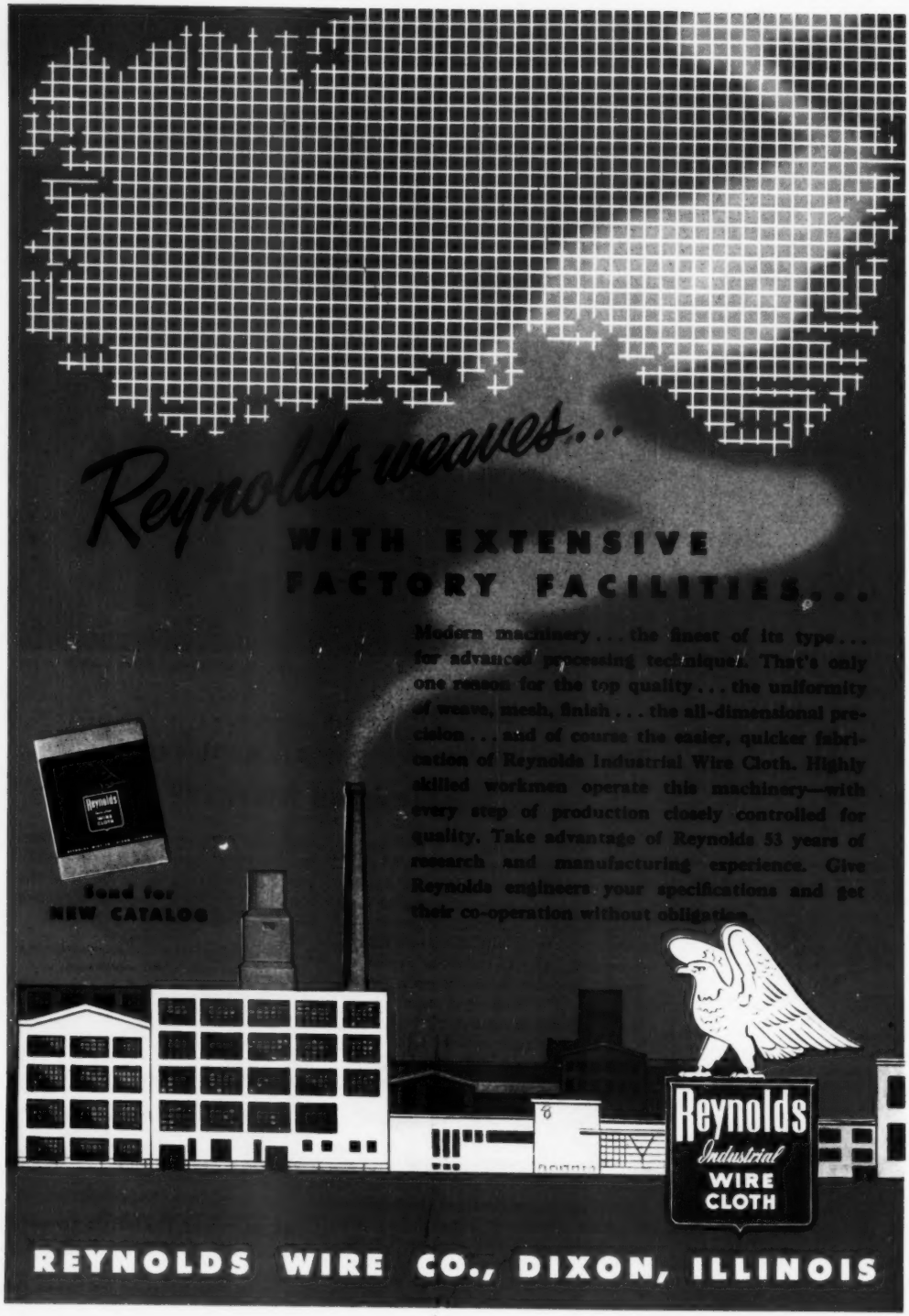
Tune in to Du Pont "CAVALCADE OF AMERICA," *Monday nights—NBC coast to coast.*

Additional information on these pumps is available—from Marine Products Company, 515 Lycasta, Detroit 14, Michigan.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In addition, Whitney Chain absorbs shock loads without breakage, assuring long operating life; while the flexibility and adaptability of chain drives simplifies design problems.

For positive power transmission specify and use Whitney Roller Chain . . . the *all steel drive*. Write for information.

CHAIN DRIVE IS BETTER

- Positive Grip
- Transmission of full horsepower
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- High load carrying capacity
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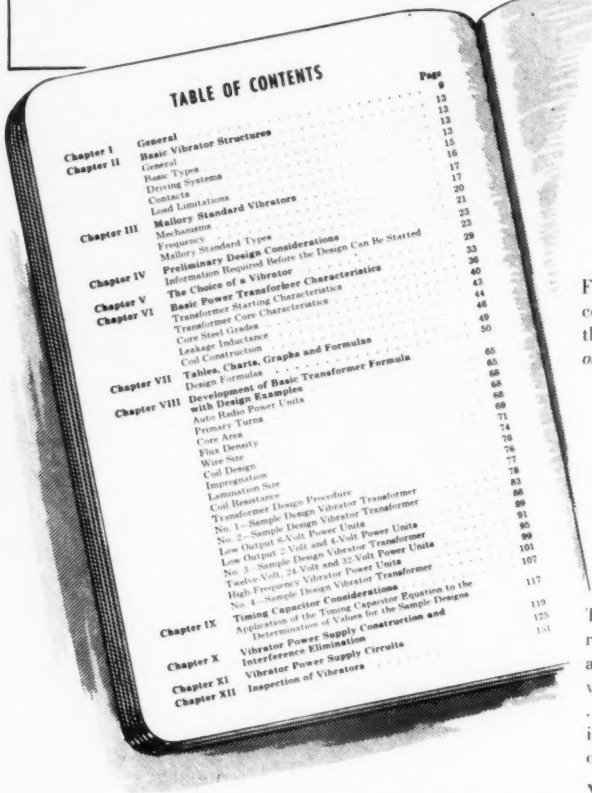
Response has been terrific!

There is still time to get your Mallory Vibrator Data Book



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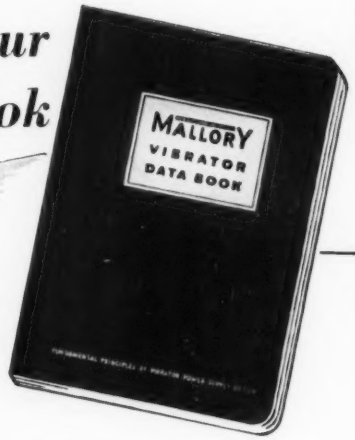

From schools, factories, and engineers all over the country have come enthusiastic letters praising the Mallory Vibrator Data Book—*the first and only one in the field.* Some typical remarks were:

> *"It is one of the finest collections of theoretical and practical data—amply illustrated, but still in one small volume."*
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> *"... your company is to be congratulated again for coming out with pertinent design data of this type."*
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The Mallory Vibrator Data Book brings you the results of eighteen years of specialized experience and research. It answers important questions on vibrator applications ... information is complete ... original ... cannot be duplicated! This book is a "must" for the library of anyone who designs or uses vibrator power supplies.

You can get your copy by ordering now. The price is only $1.00. Free to recognized engineers and teachers when requested on your letterhead.

More Mallory Vibrators are used in original equipment than all other makes combined

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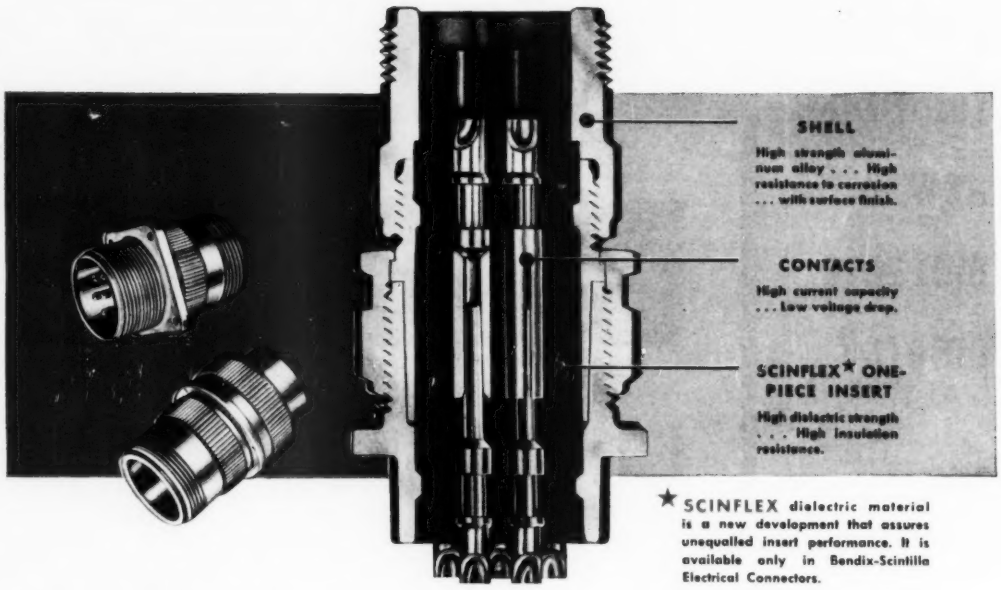
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High strength aluminum alloy . . . High resistance to corrosion . . . with surface finish.
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High current capacity . . . Low voltage drop.
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High dielectric strength . . . High insulation resistance.

★ SCINFLEX dielectric material is a new development that assures unequalled insert performance. It is available only in Bendix-Scintilla Electrical Connectors.

The use of SCINFLEX dielectric material, an exclusive Bendix-Scintilla development of outstanding stability, increases resistance to flash-over and creepage. And this is only part of the many new advantages you get with Bendix-Scintilla* Electrical Connectors. The contacts carry maximum currents with practically no voltage drop. In temperature extremes, from -67° F. to $+300^{\circ}$ F., performance is remarkable. Dielectric strength is never less than 300 volts per mil. Bendix-Scintilla Connectors have fewer parts than any other connector on the market—and that means lower maintenance costs and better performance.

*TRADEMARK

PLUS ALL THESE OTHER FEATURES

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- Radio Quiet
- Single-piece Inserts
- Vibration-proof
- Light Weight
- High Insulation Resistance
- Easy Assembly and Disassembly
- Fewer Parts than any other Connector
- No additional solder required

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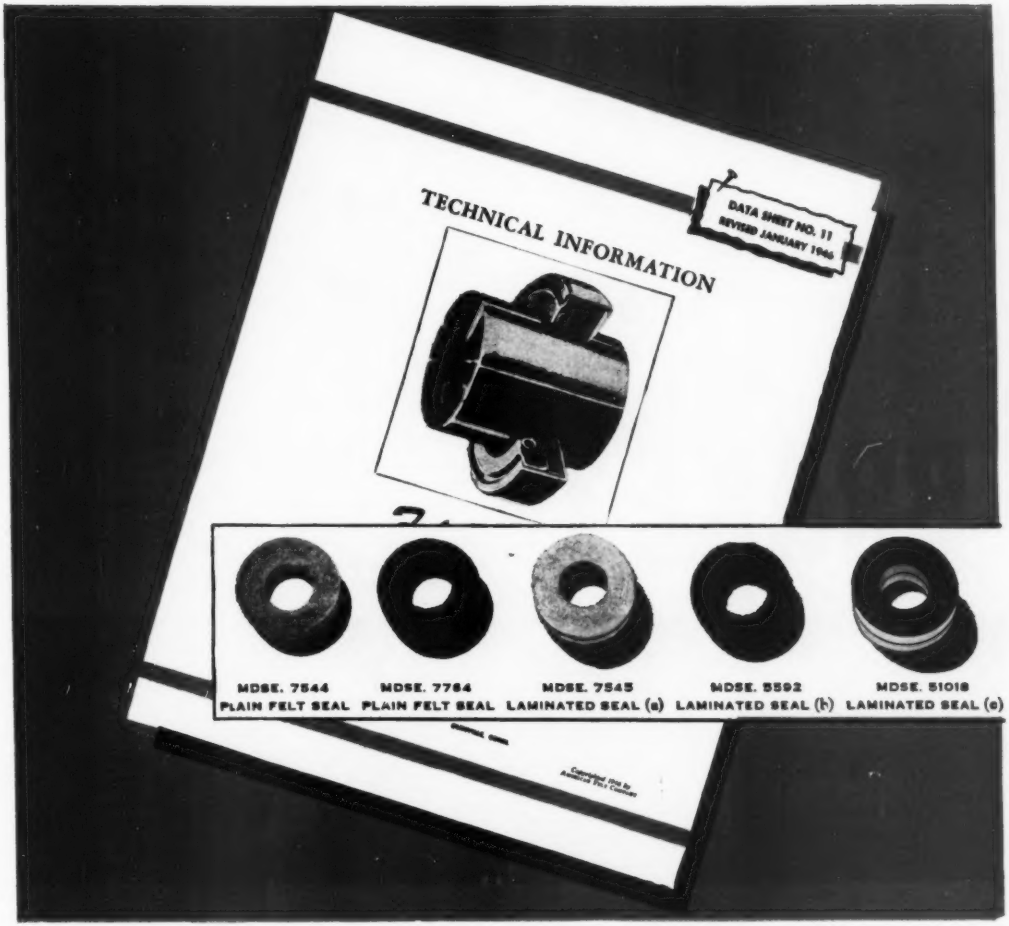

Felt Seals can work 3 ways for you

• Here are the three mechanical sealing functions performed by felt seals: (1) *they store* lubricants within themselves and hence lubricate bearings and shafts; (2) *they retain* lubricants, including pressurized, within housings, and (3) *they exclude* dust, dirt, water and other substances, giving effective protection against equipment failures due to leakage or impurities. There are many types of felt seals, both plain and laminated, to meet a wide range of conditions. For illustrative samples and complete technical information, write for Data Sheet No. 11, "Felt Seals, Their Design and Application"—an authoritative reference on this important subject. And when ordering felt for seals or other uses, be sure it is American Felt.

American Felt Company

TRADE MARK

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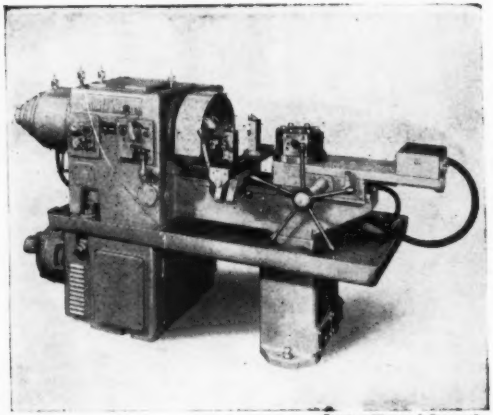
What happens-

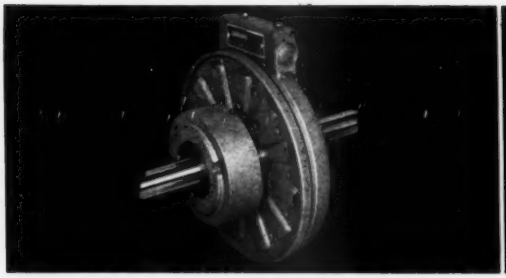
When You Give A Turret Lathe A

BRAKE?

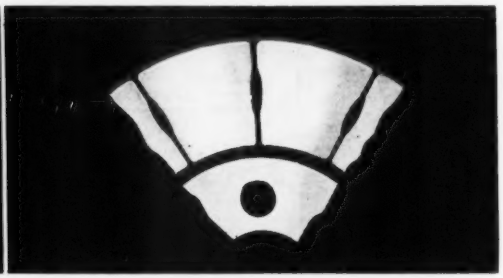


Courtesy Warner & Swasey Co

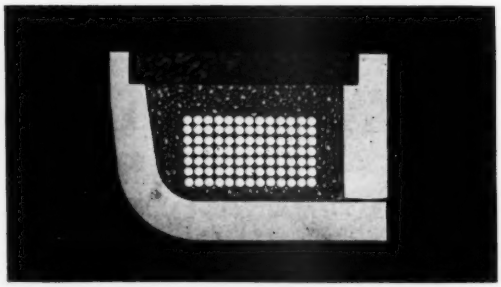
ANSWER: You reduce machine handling time and increase production because you get fast, more fully automatic cycle operation. The W & S 16" Electro-Cycle turret lathe, especially designed for machining non-ferrous metals, uses the Warner Electric Industrial Brake. It gives lightning fast spindle stops and closer spindle positioning — that means fast load and unload of workpieces.



THE BRAKE: Note compact design . . . readily adapts to machine or motor. Unit consists of only two parts . . . one fixed and one moving. Brake is automatically self-adjusting for life. Wide range of sizes to meet various requirements. Fits N.E.M.A. standard motor shafts.



ARMATURE SECTION: Armature is only moving part. Consists of magnetic material segments welded to steel back plate . . . for unmatched heat dissipation. Heat has no effect on efficiency . . . segment expansion is linear . . . keeps full magnet contact at all times.



MAGNET SECTION: Unique electro-magnet faced with extra long-wearing, molded friction material. Power is applied through coils imbedded below. Energizing applies friction *plus* magnetic attraction for super-powerful braking or clutch action.

• Warner ICB Units* are low-cost key to more automatic, safer operation of wide variety of motors and machinery . . . give you infinite control of degree of clutch or brake action. For details or engineering assistance write: WARNER ELECTRIC BRAKE MFG. CO., Beloit, Wis.

WARNER
ICB UNIT

*ICB Unit — The trade designation for the Warner Electric INDUSTRIAL CLUTCH OR BRAKE UNIT.

Sealing cover plates that position internal parts

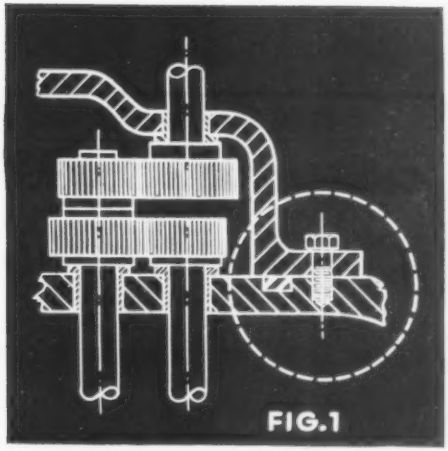


FIG.1

FIG.2A

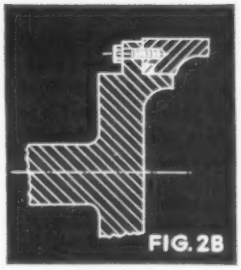


FIG.2B

Where a removable cover plate positions internal parts, a metal-to-metal joint provides positive alignment and rigidity.

The most practical sealing material for metal-to-metal joints is one that is truly compressible. Truly compressible gaskets do not side flow under pressure. They deflect only in the direction of the applied load. Hence they won't extrude and interfere with correct mating of the flanges.

Typical of truly compressible materials, Armstrong's DC-100 Cork-and-Neoprene will compress up to 33% without appreciable side flow. And with most fluids, its resistance is equal to straight Neoprene.

Used to seal the flange in figure 1, DC-100 replaced a flat paper gasket. Variations in paper thickness had caused misalignment of internal parts. The confined cork-rubber gasket insures positive alignment and provides a lasting, oiltight seal.

The flanged journal of a calender roll was sealed by a flat rubber gasket as in figure 2a. Each time worn journals were replaced, however, lack of parallelism made a costly grinding operation necessary.

The journal, modified in figure 2b, permits quick, on-the-job replacement with positive alignment. The cork-and-rubber gasket seals coolants and compresses to permit perfect mating of the flanges.

Armstrong's cork-and-rubber is made with natural or synthetic rubber to obtain the desired solvent resistance. By adding calculated amounts of compressible cork to these non-compressible rubbers, Armstrong produces compounds in which side flow is controlled within specified limits.

Versatile cork and rubber may help solve your sealing problems. We suggest that you discuss your application with an Armstrong representative. He can suggest suitable materials and supply samples for experimental use.

Send for this gasket handbook

You'll find useful application and specification data in the new, enlarged 24-page booklet, "Armstrong's Gasket and Sealing Materials." It contains up-to-date data on synthetic rubber, cork-and-synthetic-rubber, cork composition, and fiber sheet sealing materials.

This booklet includes ten technical discussions of the factors influencing modern gasket and joint design. It also suggests methods of putting Armstrong's stock materials to specialized uses in such fields as radio, electrical, automotive, petroleum, and transportation industries. Also included are typical applications and current government specifications.

For your free copy, fill in coupon at right and mail today.

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Please send me at once a copy of the new 24-page booklet, "Armstrong's Gasket and Sealing Materials."

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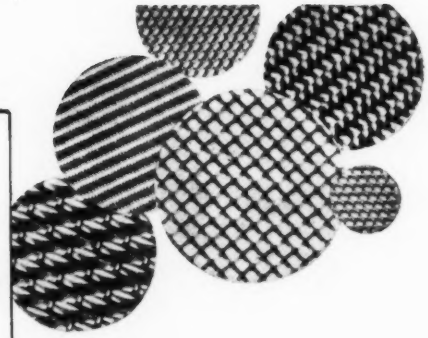
Compare this *Screen* and *Filter Cloth* with any you are now using!



HOW durable are filters, strainers and screens in the equipment you design?

They won't be sources of trouble if you use wire cloth made of Monel*, Nickel or Inconel*.

These metals are rustless...corrosion-resisting... strong...tough. They endure extremes of temperature. They stand abrasive wear.

All standard weaves and meshes are available, as well as special construction for "special" jobs. You can specify just the type you need to build long life into your products.

This cloth can be fabricated into any practical shape or size elemert. Seams are readily joined by brazing, soldering or welding; retain full corrosion resistance.

The price? It's a surprise. Due to excellent working qualities, weavers can produce wire cloth of Monel, Nickel or Inconel at prices comparable to what you are now paying for cloth of less durable metal. *Fine weaves of Monel often cost less!*

Consult any quality weaver. *He'll be glad to quote on the wire cloth you need. For booklet,* **"ESTABLISHED WEAVERS."** *write to our Frank Bailey.*

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y. *Reg. U. S. Pat. Off.

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"Task Metals" for Industry

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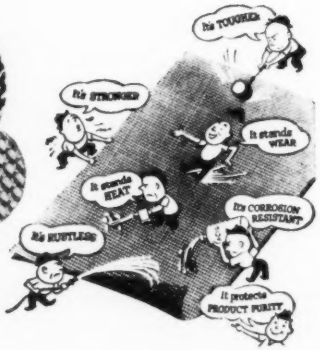


Clutch Adjustment

WITH ONE HAND SAVES TIME...MONEY

—the Red Elastic Collar helps JUMP PRODUCTION...CUT COST!

The nut and jam nut combination formerly used on the clutch adjustment rod of the Hystaway—tractor-mounted excavator manufactured by the Hyster Company at Portland, Oregon, had two disadvantages: (1) two wrenches were required to adjust the clutch (one to hold the first nut, and one to loosen and reset the jam nut); and, (2) it was difficult to get two hands through the limited frame opening.

After exhaustive experimentation, the Company adopted Elastic Stop Nuts. Now clutch adjustment can be made quickly, easily and *exactly—with one hand.*

Further, since Elastic Stop Nuts lock in position anywhere on a bolt or stud, only one adjustment is usually necessary—the first. Once this adjustment is made, the Red Elastic Collar maintains that precise setting permanently. Neither vibration nor impact will shake the nuts loose. Also, Elastic Stop Nuts keep bolt and nut threads rust-free . . . seal against liquid seepage along bolt threads . . . do not damage the threads. And, of course, Elastic Stop Nuts are re-usable.

HERE'S A CHALLENGE: Send us complete details of your toughest bolted trouble spot. We'll supply test nuts—FREE, in experimental quantities. Or, if you want further information, write Elastic Stop Nut Corporation of America, Union, N. J. Representatives and Agents are located in many principal cities.

ESNA TRADE MARK

THE FAMOUS RED ELASTIC COLLAR IS VISIBLE EVIDENCE OF LOCKING SECURITY

Threadless and permanently elastic, it provides these 4 outstanding features:

1. **Protects against nuts loosening due to VIBRATION**
2. **Keeps locking threads CORROSION FREE**
3. **Provides for accurate BOLT LOADING**
4. **Seals against LIQUID LEAKAGE along the bolt threads**

ELASTIC STOP NUTS

HIGH TENSILE

ANCHOR

WING

SPLINE

CLINCH

GANG CHANNEL

NYLON CAP

OVER 450 TYPES AND SIZES IMMEDIATELY AVAILABLE FROM STOCK

THERE'S NO QUESTION ABOUT THE TENSION

For the "know-how" to obtain and hold correct spring tension is Gibson's long suit! Every safeguard in design, toolmaking, production, heat-treating and finishing is aimed at one result—uniform, long-lived spring action. We'll be glad to relieve the "tension" in your plans for mechanical motion. Gibson puts it where it belongs—in the spring.

SMOOTH ACTING

GIBSON-SPRINGS

CLIPS • SMALL STAMPINGS
CLAMPS • WIRE FORMS

The William D. Gibson Co.

DIVISION OF ASSOCIATED SPRING CORP.
1800 CLYBOURN AVE., CHICAGO 14, ILL.

here's on-the-job proof of Westinghouse Instrument Performance

where reliability and readability really count

Radio stations can take no chances on "outages"—time off the air is costly. For split-second timing, efficiency, and continuity, all vital operating information must be readily available to the control engineer at a glance.

For these reasons, instruments of unfailing performance and quick readability are a *must*. The Westinghouse instruments at KMOX solved these problems. They also provide co-ordinated styling and smart appearance.

What are YOUR electrical measuring problems?

Would they include—reliable performance . . . styling . . . size . . . readability or different types of service . . . portable . . . switchboard . . . panel . . . recording?

The vast lines of Westinghouse electrical measuring instruments provide you with the answers to all of these problems. Every Westinghouse instrument is backed up by more than 60 years of skill, "know-how", and experience in every field of industry. J-40362

Westinghouse Instruments Also Provide You With

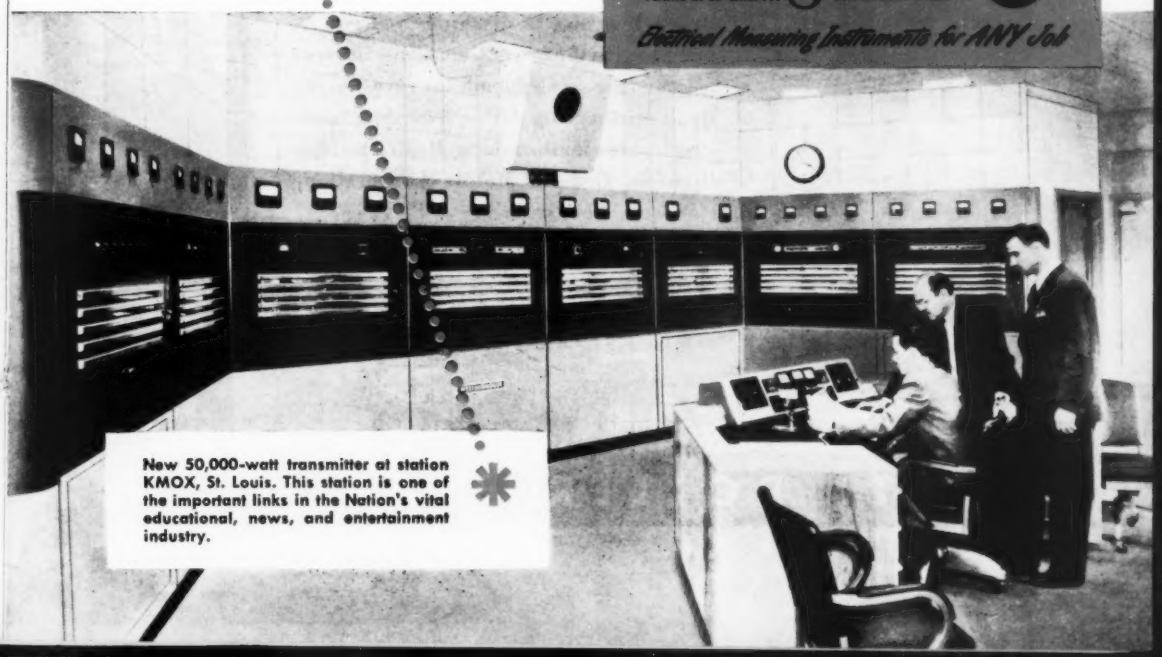
- Dials that *stay* white under all conditions
- Magnets that stay permanent
- Pivots with high shock capacity and low friction
- Springs that remain constant for life
- Quick delivery of more different ratings and types
- Complete Nationwide Service

Westinghouse instrument specialists are available in the field for consultation on your instrument problems. Call your nearest Westinghouse office, or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa.

Send for Booklet B-2209-A, Communication Instrument Booklet B-3283, or Switchboard Instrument Booklet B-3363.

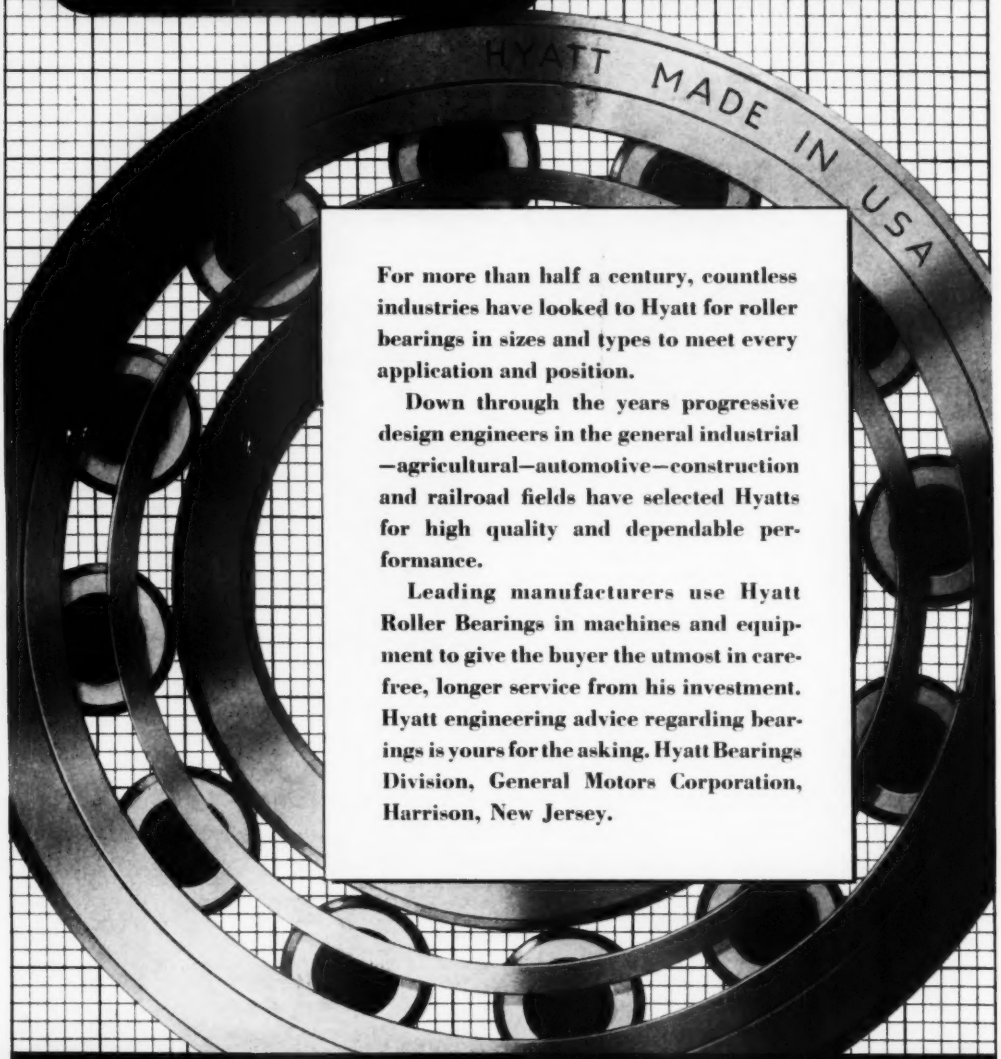
YOU CAN BE SURE . . . IF IT'S Westinghouse

Electrical Measuring Instruments for ANY Job



New 50,000-watt transmitter at station KMOX, St. Louis. This station is one of the important links in the Nation's vital educational, news, and entertainment industry.

There were no
Roller Bearings
before Hyatt made them



For more than half a century, countless industries have looked to Hyatt for roller bearings in sizes and types to meet every application and position.

Down through the years progressive design engineers in the general industrial—agricultural—automotive—construction and railroad fields have selected Hyatts for high quality and dependable performance.

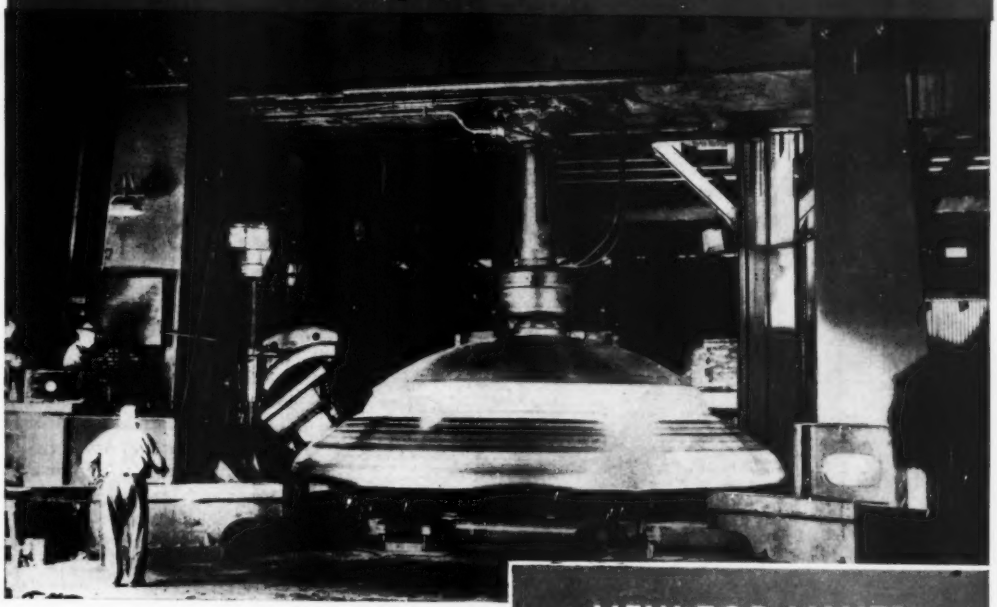
Leading manufacturers use Hyatt Roller Bearings in machines and equipment to give the buyer the utmost in carefree, longer service from his investment. Hyatt engineering advice regarding bearings is yours for the asking. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

HYATT ROLLER BEARINGS

Lukens now spins the

WORLD'S LARGEST HEADS

. . . up to 20'6" O.D.

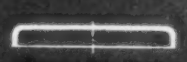


It's another "World's Largest" for Lukens—this new machine, capable of spinning heads up to 20′ 6″ in outside diameter. Now it is seldom necessary to resort to sectional flanging of heads with accompanying construction and X-raying problems.

64 years of head-forming experience at Lukens went into the design of this new machine. That same know-how guides the production of Lukens Heads in the widest range of sizes, gages, styles and materials obtainable, including Clad Steels and nonferrous metals from 4″ to 20′ 6″ in diameter, or from 3/16″ to 6½″ thick.

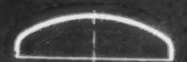
In addition to the 3989 standard Lukens Heads listed in Catalog No. 1, obtainable promptly from dies available, Lukens has many sizes of Standard and ASME Flanged and Dished Heads in stock listed in Bulletin 433. For copies, write Lukens Steel Company, 405 Lukens Building, Coatesville, Pennsylvania.

NEW TOP LIMITS



Flanged Only Heads
Maximum—20' 6" O. D.

Standard Flanged & Dished
Maximum—20' 6" O. D.



ASME, API-ASME Flanged
& Dished, Maximum—
20' 6" O. D.

Elliptical Flanged
& Dished, Maximum—
18' 0" I. D.

LUKENS HEADS

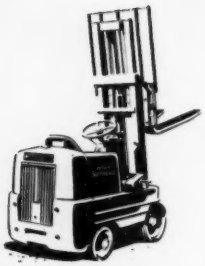
★

"Head Work", a 16mm motion picture in sound and color, on spinning and pressing of Lukens Heads is available without charge. Running time: 27 minutes. Write for a booking date.

FOUR INCHES TO OVER TWENTY FEET IN DIAMETER

. . SPEED SCRAP TO THE MILLS TO MAKE MORE STEEL . .

For POWER,



There's a Great New Ford Industrial Engine that's RIGHT for Your Job

Ford Power is RIGHT 3 Important Ways

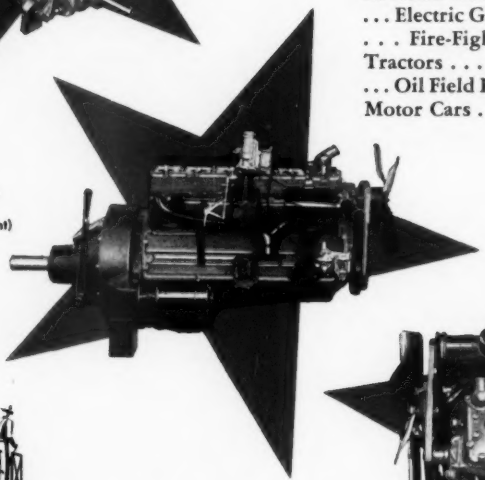
1. **RIGHT POWER**—Your choice of five rugged workhorses in the complete Ford Industrial Engine line. There's one just right for your job.
2. **RIGHT FEATURES**—You're always right up to date when you specify Ford Power. Every model has all the latest benefits of Ford's famed progressive engineering.
3. **RIGHT SERVICE**—Ford Dealers are everywhere, with the facilities and experience for keeping Ford Industrial Engines right on the job—for longer life, greater service, lower costs.

Ford 120 Four Cylinder Industrial Engine (120 cu. in. displacement)

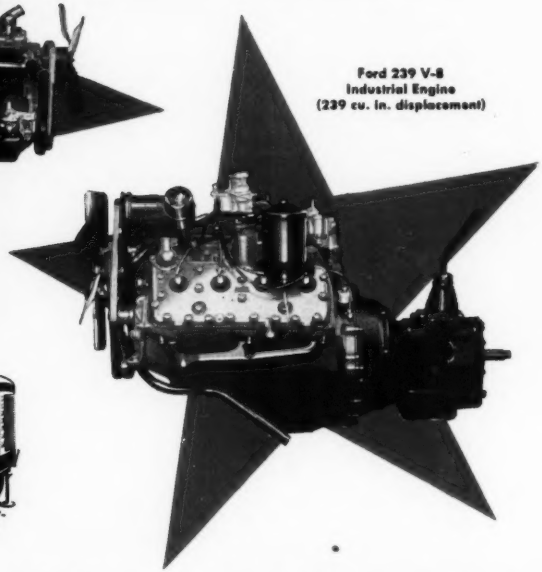
Ford Industrial Engines Power—

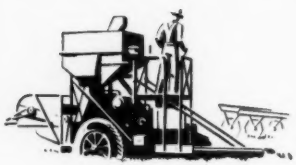
Agricultural Machinery . . . Orchard Equipment . . . Air Compressors . . . Road and Construction Machinery . . . Derricks and Hoists . . . Electric Generating Plants . . . Arc Welders . . . Fire-Fighting Equipment . . . Industrial Tractors . . . Lumber and Sawmill Equipment . . . Oil Field Equipment . . . Pumps . . . Railway Motor Cars . . . and many other applications.

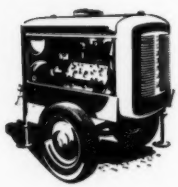
Ford 226 Six Cylinder Industrial Engine (226 cu. in. displacement)



Ford 239 V-8 Industrial Engine (239 cu. in. displacement)







YOUR JOB IS WELL-POWERED

Pick FORD

Only Ford Industrial Engines Have All These Features

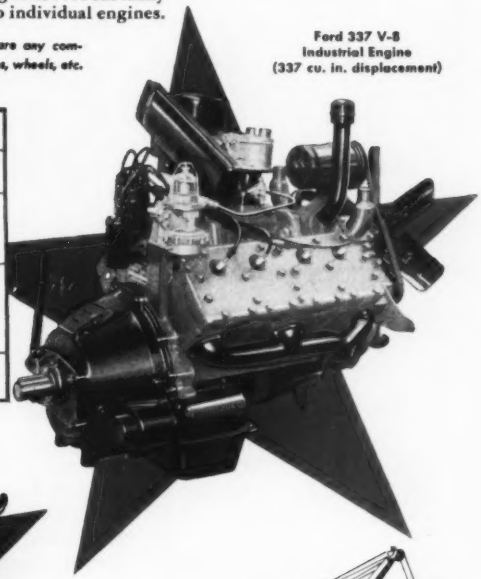
Made throughout to Ford famed hi-precision manufacturing standards . . . Fully counterbalanced crankshafts . . . Large, precision, replaceable main and connecting rod bearings . . . Long life, high-chrome nickel alloy valves . . . Moly-chrome alloy steel valve seat inserts . . . Shot-blasted, rust-proofed valve springs . . . Full-floating, tubular piston pins . . . Full pressure lubrication to all bearings . . . Deep oil pans with clean-out plates . . . Direct, gear-driven camshafts with aluminum timing gear . . . Removable cartridge type oil filters . . . Hi-capacity, full-jacketed, thermostatically controlled cooling . . . Balanced carburetion . . . Full-automatic distributors . . . Drop-forged connecting rods . . . Plus many other advancements applying to individual engines.

Also available to manufacturers, through the Industrial Engine Department, are any component Genuine Ford Parts including front and rear axles, transmissions, brakes, wheels, etc.

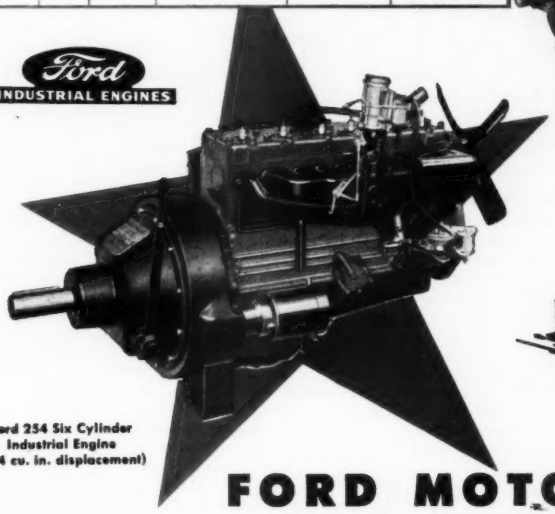
Specifications of Ford Industrial Engines

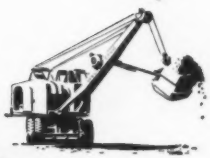
Model	Cylinders	Bore and Stroke	Displ. cu. in.	Dyn. B.H.P.	Max. Torque	Auxiliary Equipment Available
120	4	3⅛x3¾	120	36@2400	84#' @1600	Clutch; 3 and 4 speed transmissions; SAE #5 housing and power take-off. Also complete power unit.
226	6	3.3x4.4	226	80@2400	182#' @1200	Clutch; 3, 4 and 5 speed transmissions; SAE #3 and #4 housings; power take-off.
239	V-8	3⅛x3¾	239	85@2400	187#' @1600	
254	6	3.5x4.4	254	95@2400	212#' @1200	
337	V-8	3½x4⅓	337	117@2400	257#' @1600	Clutch; 5 speed transmission; direct drive power take-off.

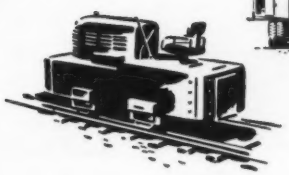
Ford 337 V-8 Industrial Engine (337 cu. in. displacement)



Ford INDUSTRIAL ENGINES







Ford 254 Six Cylinder Industrial Engine (254 cu. in. displacement)

FORD MOTOR COMPANY

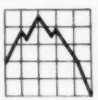
INDUSTRIAL AND MARINE ENGINE SALES DEPARTMENT • DEARBORN, MICHIGAN

WHEN IT'S FORD-POWERED

CHECK THESE BW ADVANTAGES

No vents or exhaust fans: The Bruning Model 93 is completely odorless . . . can be used anywhere in the office without the slightest offense.

No plumbing connections: There are no pipes to connect, no water to supply or drain away. The Model 93 is mounted on casters, is moved where needed.



Built-in transformer: The Model 93 is the first large volume whiteprinter which protects you against voltage fluctuations common to power lines. Assures longer lamp life, more uniform prints, as well as savings on BW Materials.

Uniform developing: Both sides of the print receive a thin, measured film of BW Developer Solution at once. This assures flat prints, never under- or over-developed.

Other Bruning Products you should know about

Drafting Machines • Sensitized Papers & Cloth • Tracing Papers • Erasing Machines Drafting Room Furniture • Slide Rules Surveying Instruments • and many others.

BRUNING BW WHITEPRINTER 93

VOLUMATIC MODEL

Now *all* your departments can handle their copying jobs with a single versatile machine: the Bruning Whiteprinter, Volumatic Model 93. This brand new machine at last provides you the necessary volume and high speed (up to 105 sq. ft. per minute). At the same time, through simpler operations and less wastage, it reduces copying costs.

The Volumatic produces sharp, highly legible copies of engineering drawings, documents, or *anything* that is printed, drawn, written, or typed on a translucent medium. It copies charts, plats, letters, invoices, financial reports—and many other items. Its operation is so simple that a girl can learn to run it in less than an hour.

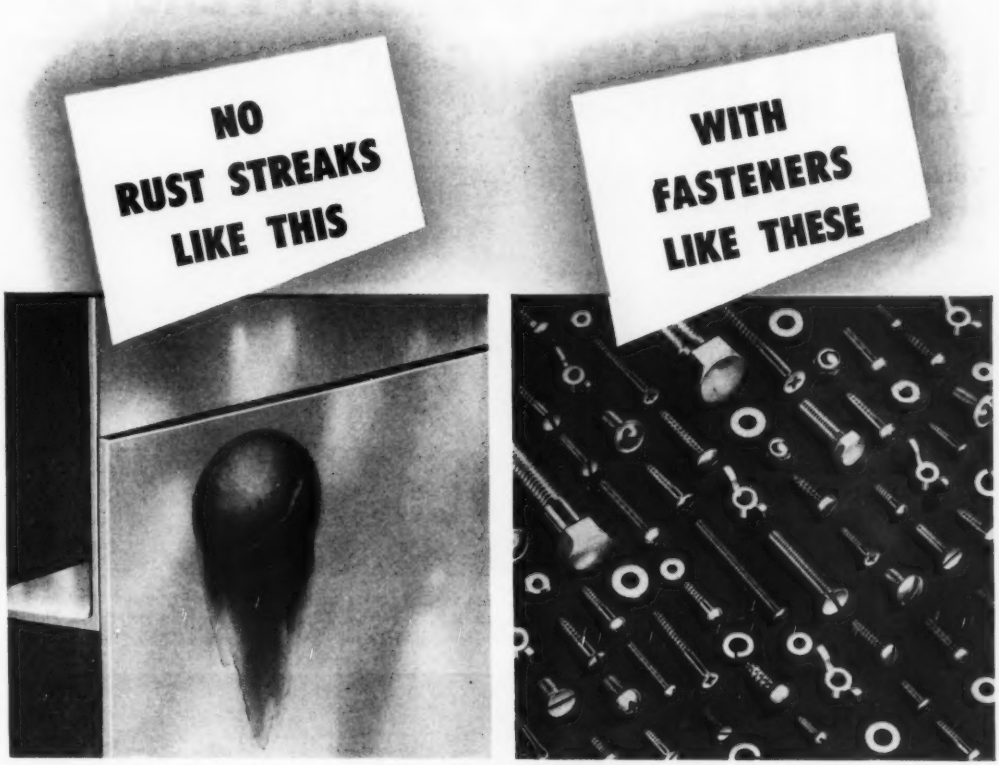
The Volumatic takes cut sheets or roll stock with equal facility. It produces sharp BW Prints from post card size up to 42 inches wide and of unlimited length. You can have light, medium, or card-weight BW Prints; BW Prints on tinted stocks; BW Prints on film or cloth; or BW Prints with colored lines. BW Prints are delivered front or rear, neatly stacked.

Send today for full information. Let us send you a file of literature describing the new BW Volumatic Model 93 and other Bruning Whiteprinters, and the BW Mediums you can use with them. See for yourself the extreme versatility, economy, and speed of these machines. There is no obligation.

Charles Bruning Company, Inc.

4736-44 West Montrose Avenue, Chicago 41, Ill.

New York • Newark • Boston • Pittsburgh • Chicago • Detroit
Cleveland • Milwaukee • St. Louis • Kansas City, Mo. • Houston
Los Angeles • San Francisco • Seattle



Alcoa Aluminum Fasteners offer you corrosion resistance at lowest cost

Alcoa Fasteners are corrosion resistant all the way through—won't ever red rust-streak your aluminum assemblies. Made of tough aluminum alloy, they pull up into a strong, tight joint.

Alcoa Fasteners are available from stock with Phillips or slotted heads; in sheet metal, wood and machine screws; standard threads in all popular sizes and head types; nuts, bolts, washers, lock washers, solid or tubular rivets and cotter pins also available.

Investigate the low cost and sales advantages Alcoa Fasteners can give you! Write today, on your letterhead, for free samples to ALUMINUM COMPANY OF AMERICA, 618 Gulf Bldg., Pittsburgh 19, Penna. Please specify types and sizes.

ALCOA *Aluminum* FASTENERS

UNUSUAL NEW DU PONT PLASTIC USED IN VARIETY OF NEW PRODUCTS

Versatile polythene promises to play big part in future of American industry

Have you seen the new ice tray that releases its cubes at a twist of the wrist? Or have you seen those new *bottles* that spray out their contents when squeezed . . . and *won't break* when dropped?

These and hundreds of other fascinating new products are being made of Du Pont polythene . . . one of the most remarkable materials of modern chemistry.

Polythene molding powders are made in a wide range of colors by the Plastics Department of the Du Pont Company. Extruders, molders, and other processors convert the material into molded products, film, tubing, tape, filaments, etc.

In thin sections, polythene is tough and flexible. A new baby bottle made of polythene is soft, pliable, and strong. It needs no sterilizing. And it costs so little it *can be thrown away after use.*

In thick sections, such as pipe, polythene is relatively rigid. It resists most chemicals. As tubing it can be bent around corners, and rolled like a cable for easier handling.

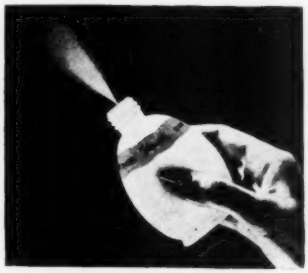
During the war, polythene first came into use as an insulation material for high-frequency wire and coaxial cable. Since then it has found wide use in the electrical field. Current uses include jacketing for power cables and insulation for the coil in a new watt-hour meter.

Polythene's unusual combination of properties is especially useful in the packaging field. It can be heat-sealed. It keeps out water, dust, and bacteria. And it stays tough and strong at low temperatures . . . is tasteless, odorless, and nontoxic. Items now packaged in polythene include foods, cosmetics, corrosive chemicals, and metal parts.

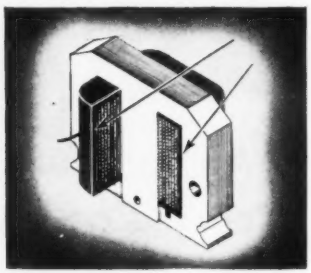
Manufacturers are making more and more new products of all types with Du Pont polythene. For polythene offers so many advantages at low cost—including ease of molding, extrusion and machining.

The demand for polythene still exceeds the supply, but continuing increases in production are being pushed to catch up with demand. More information on uses and specific properties of polythene can be obtained from E. I. du Pont de Nemours & Co. (Inc.), Plastics Department, Empire State Building, 350 Fifth Avenue, New York 1, N.Y.; 7 South Dearborn Street, Chicago 3, Illinois; 845 East 60th Street, Los Angeles 1, California.

APRON, pitcher, tumblers, ice-cube tray, ice tub, bowls, sugar bowl, cream pitcher and tablecloth protector are all made of Du Pont polythene. Names of manufacturers of items shown above available on request.



SQUEEZABLE BOTTLES, blow molded from polythene, package products ranging from cosmetics to corrosive chemicals. (Deodorant bottle molded by Plax Corp., Hartford, Conn., for Jules Montenier, Inc., Chicago.)



POTENTIAL COIL for new watt-hour meter is insulated with Du Pont polythene for greater strength, reliability and secure positioning. (Watt-hour meter manufactured by General Electric Co., Schenectady, N. Y.)

DISPOSABLE BABY BOTTLE made from Du Pont polythene extruded as continuous, flat, sterile tubing; heat-sealed to form 4- or 8-oz. sections. (Made by Shellmar Products Corp., Mt. Vernon, Ohio.)

THIS PHOTO OF FINISHES HAS STARTED A RACE

Here are some of the available patterns. From left to right: grained leather, squares, stucco, diamonds, ribs horizontal, and ribs vertical.

New Reynolds Embossed Aluminum Sheet Eliminates Surface Finishing

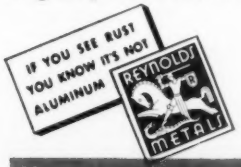
ANOTHER amazing development in aluminum from Reynolds! This time it's aluminum sheet with the new beauty of embossed finishes. Watch wise manufacturers rush to take advantage of this development, because it brings sweeping fabrication economies. Look for attractive new products, too, when designers get going with this new idea.

For example, an embossed finish offers you a partially fabricated product . . . provides big savings over involved finishing methods. And it's a better finish that adds new beauty. Scratches won't show, glare is cut, and you know aluminum won't rust. Embossing also affords selective stiffness or greater over-all rigidity, according to the pattern chosen. Embossed sheet can be drawn, formed, etched, or welded. Available now in quantities for development work.

The race has already started—manufacturers are using the patterns shown above for a host of better products . . . from panels on coin merchandising machines to truck body sections, and even for roofing. These users are also enjoying the other advantages of aluminum . . . such as three times the metal per pound to work with, less handling cost due to reduced weight, lower shipping cost. Aluminum is easier to work, faster on production lines. It offers smart new styling for products.

For information on this new embossed sheet and every kind of aluminum to economically improve your product, call your Reynolds Distributor or the nearest Reynolds Office, listed under "Aluminum" in the classified section of your telephone directory, or write to Reynolds Metals Company, Aluminum Division, 2545 South Third St., Louisville 1, Kentucky.

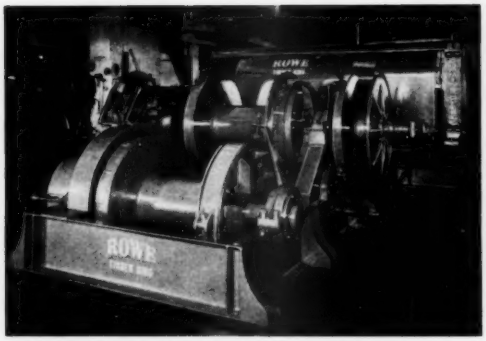
FINISHES FOR ALUMINUM
Send your request for this informative book on your company letterhead and receive your copy without charge.



REYNOLDS Lifetime ALUMINUM

REYNOLDS PIONEERING MADE ALUMINUM COMPETITIVE . . . TAKE ADVANTAGE OF IT!

Torrington Spherical Roller Bearings Stand Up to Shock and Deflection In Rowe Timber King Yarders



For handling heavy materials like logs, beams and pipe, Timber King Yarders have to be rugged. To back up a 32-ton line pull, and make sure each Yarder will stand up to hard usage and severe shock, Rowe Machine Works uses 6 Torrington Spherical Roller Bearings on main, haulback and strawline drums.

These precision bearings give the low torque that means easy starting under heavy loads, smooth running with low power consumption. When shock loads deflect drum shafts or distort yarder frames, Spherical Roller Bearings compensate automatically for misalignment, keep rolling effortlessly.

Easy handling and installation of Spherical Roller Bearings, due to their unit design, is appreciated both in assembly and servicing. Readily accessible, the bearings, reduce down time in the field. Were it necessary, two men could easily dismount and remount all six bearings in a day.

Welded construction of yarder frames would make it difficult to secure accurate alignment with rigid bearings. Spherical Roller Bearings make proper initial and running alignment a matter of course. Time is saved in assembly. Long service life is assured under the most severe operating conditions.

In equipment you build or operate, specify Torrington Spherical Roller Bearings for long service life and minimum maintenance attention. Our engineers offer their experience to help you with your friction problems. Write us today. THE TORRINGTON COMPANY, South Bend 21, Ind. or Torrington, Conn. District offices and distributors in principal cities.

TORRINGTON SPHERICAL ROLLER **BEARINGS**

Spherical Roller • Tapered Roller • Straight Roller

Needle • Ball • Needle Rollers

In this modern midwestern dairy, all process tubing and piping are made of easy-to-clean, sanitary stainless steel tubing and pipe. And in keeping with the bright, gleaming appearance of the processing equipment, even the air lines and electrical conduit are made of stainless steel tubing.

● In the processing of food, chemicals, pharmaceuticals and many other products, there can be no compromise with cleanliness, sanitation and freedom from contamination. That's why ELECTRUNITE Tubing and Pipe—made of gleaming Republic ENDURO Stainless Steel—are widely used for countless applications in these fields.

Because stainless steel inherently is a sanitary, non-contaminating material, ELECTRUNITE Stainless Steel Tubing automatically affords these basic advantages. And as produced by Republic's *improved* electric welding processes, this *modern* tubing is uniformly ductile, strong, sound and round . . . free from scale and scale pits both inside and out.

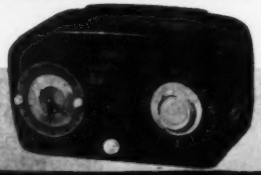
Where purity is all-important, the extra cost of stainless steel is extremely inexpensive insurance against sub-standard product quality. For complete information about ELECTRUNITE Stainless Steel Tubing and Pipe, write today for the name and address of your nearest ELECTRUNITE Distributor.

REPUBLIC STEEL CORPORATION
STEEL AND TUBES DIVISION • CLEVELAND 8, OHIO
Export Dept.: Chrysler Bldg., New York 17, N. Y.

Republic
REPUBLIC STEEL
ELECTRUNITE
STAINLESS STEEL TUBING

It pays to use your custom molder's know-how

say Jewel Radio Executives



No. 4 in a Series on Plastics Skill at Work...

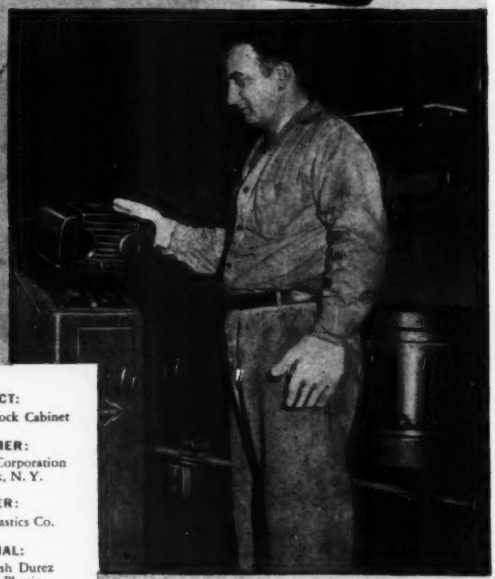
PROJECT:
Radio and Clock Cabinet

CUSTOMER:
Jewel Radio Corporation
New York, N. Y.

MOLDER:
Tech-Art Plastics Co.

MATERIAL:
Mottle-Finish Durez
Phenolic Plastic

CHANGING HOLE LOCATIONS on the bottom of the cabinet was required for various production runs. Tech-Art's solution was to use modern multihead drills instead of a cam action mold.



HIGH RATE OF PRODUCTION was achieved for this customer by using semi-automatic compression presses and Thermall electronic pre-heating equipment in molding the Durez plastic cabinets.

● "How many can we turn out...how fast?" An experienced custom molder sitting in at your planning councils can often raise the number that you'd get otherwise.

The Jewel Radio Corporation showed Tech-Art Plastics Co. the sketches of a new radio and clock cabinet. Fast work was urgently wanted...and the finished cabinet weighing almost two pounds would need a rather large mold.

Despite this, Tech-Art engineers offered constructive suggestions, designed the mold, recommended a general-purpose Durez phenolic plastic, and went into production within 10 weeks.

When a second mold and production line method were put into operation, the molder produced at the unusually high rate of 1800 cabinets per day. This schedule of deliveries is being held month after month on a seven-day-week basis.

Since the success of any part depends on the material used in it, Durez field technicians often team up with molders and customers in product planning.

We'll gladly serve you...and our experience as phenolic specialists covers the entire history of the industry.

A new hit with plastics users everywhere is the handy "Durez Check-Chart." Write for yours. Durez Plastics & Chemicals, Inc., 154 Walck Rd., N. Tonawanda, N. Y.

DUREZ

PHENOLIC RESINS

- MOLDING COMPOUNDS
- INDUSTRIAL RESINS
- PROTECTIVE COATING RESINS

PHENOLIC PLASTICS THAT FIT THE JOB

bend it...
twist it...
stamp it...
spin it...
Use any standard fabricating method you wish!
The bond is inseparable!
SuVeneer Clad Metal's solid copper, monel or nickel cladding is bonded to low-carbon strip steel for keeps! It cannot be separated by mechanical means—you can use full freedom in new product design and count on dependable fabrication results. Get the special benefits of these solid metals combined with a strip steel base—specify and use SuVeneer Clad Metal!
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CLAD METAL
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Monel Clad
Nickel Clad
Superior Steel
CORPORATION
CARNEGIE, PENNSYLVANIA

Thermostat Metal Tolerances of Plus or Minus .0000000000

NO We're Not Quite That Good But We Are Getting Closer Every Day!

Sounds ridiculous that tolerances can be held to the "Nth degree" . . . but at General Plate we are getting closer to it every day because it has become increasingly important that thermostat metals be accurately rolled. In fact, one of our customer's "specs" calls for Truflex Thermostat Metal with a tolerance ± .00005, . . . and through our high precision-manufacturing process, we are meeting it with every delivery.

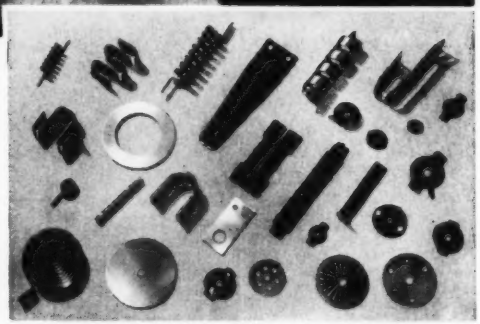
General Plate manufactures Truflex Thermostat Metals in a complete line of combinations large enough to meet all requirements in temperature range, electrical resistance, size, shape and cost. Truflex Thermostat Metals are available in raw stock in sheets and coils . . . or completely fabricated parts ready for assembly into your products.

It will pay you to investigate General Plate Truflex Thermostat or Contact Metals. Write for information and engineering assistance.

GENERAL PLATE

Division of Metals and Controls Corporation

104 FOREST STREET, ATTLEBORO, MASSACHUSETTS



Typical Truflex formed elements and assemblies.

MAIL COUPON TODAY!

GENERAL PLATE Division of Metals and Controls Corporation
104 FOREST ST., ATTLEBORO, MASS.

Gentlemen:
Please send me information on Truflex Thermostat Metals.

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Title _____

Address _____

1-449

WHEN TO USE SINGLE-ROW RADIAL-THRUST BEARINGS

If your application requires maximum capacity for thrust loads in *one direction only* or *combined radial and thrust loads* with predominant thrust load, specify Federal Ball Bearing Series 7200, 7300 or 7400.

These Federal bearings are so engineered that the angle of contact between the balls and the races will be more nearly in line with the resultant pressure from combined thrust and radial loads than would be the case with single row radial ball bearings. Higher outer ring shoulders on the thrust side and deep, continuous inner ring raceways assure maximum ball contact area. The low outer ring shoulder opposite the thrust face permits the use of the maximum number and size of balls. These features give Federals their consistently high load carrying capacity. The bearings are non-separable after assembly and not adaptable for pure radial loads.

Federal Single-Row Radial-Thrust Bearings are made in light, medium and heavy series to cover a wide range of applications. Our Catalog "K" includes ball bearing selection charts to help you compute bearing loads, determine load ratings for all bearings at all speeds, and select the type and size ball bearing best suited to your application. It also describes these and one of the most complete lines of ball bearings...every type and size...shielded and sealed...for every anti-friction need. (A few of the many types are illustrated above.) Write for your copy today.

THE FEDERAL BEARINGS CO., INC. • POUGHKEEPSIE, NEW YORK

Makers of Fine Ball Bearings

REPRESENTATIVES LOCATED AT

2640 Book Tower, Detroit 26, Michigan • 8 South Michigan Ave., Chicago 3, Illinois
402 Swetland Building, Cleveland 15, Ohio

FEDERAL BALL BEARINGS

ONE OF AMERICA'S LEADING BALL BEARING MANUFACTURERS

Cold-Formed Shapes

used by maker of confectionery equipment

The cold-formed shape shown here serves as a chain guide in multi-tier cooling conveyors produced by a leading manufacturer of confectionery and bakery equipment, who reports it much more economical and practical than the part produced by welding, formerly used. We make it on cold-roll forming machines from 10 gauge steel strip, and furnish it to the customer in long lengths.

Chain guides are but one of scores of ways in which Bethlehem Cold-Formed Shapes are being used today in many types of industry. And week after week new uses, some so original that they come as a surprise even to us, are being discovered for these versatile shapes.

Bethlehem Cold-Formed Shapes are produced from strip, sheets or plates. They are uniform in thickness, and economical to install and use. They have an excellent strength-weight ratio, and a relatively scale-free surface. We make them in all gauges from 7 to 24, inclusive, our complete shop facilities enabling us to meet practically every need.

You may not have suspected it, but there may be a place where Bethlehem Cold-Formed Shapes could be used to advantage in your business. We'll look into it for you, if you wish.

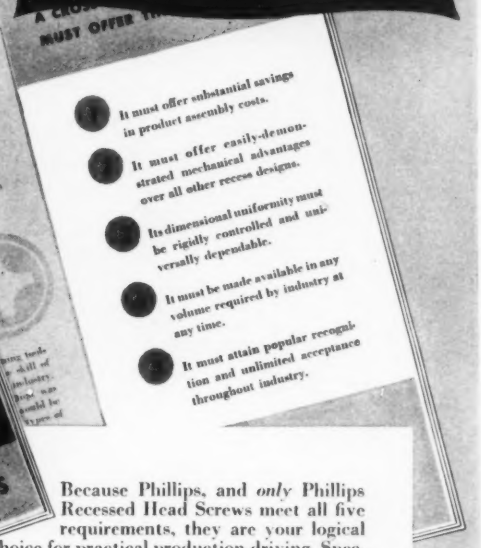
BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by
Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

★ BETHLEHEM STEEL ★

This booklet tells you why...

ONLY PHILLIPS SCREWS offer these 5 essentials of a STANDARD Cross Recessed Head Screw


It must offer substantial savings in product assembly costs.
It must offer easily-demonstrated mechanical advantages over all other recess designs.
Its dimensional uniformity must be rigidly controlled and universally dependable.
It must be made available in any volume required by industry at any time.
It must attain popular recognition and unlimited acceptance throughout industry.

Because Phillips, and *only* Phillips Recessed Head Screws meet all five requirements, they are your logical choice for practical production driving. Specify Phillips and gain *all* the advantages that *standard* Cross Recessed Head Screws can contribute to your product's manufacture.

Everyone in Industry responsible for screw selection should have this Fact-Full Booklet.

It lets you in on the important facts you can't afford to overlook when you choose cross recessed head screws. It's FREE. Use the coupon . . . send it today.

PHILLIPS *Recessed Head* SCREWS

Wood Screws • Machine Screws • Self-tapping Screws • Stove Bolts

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Elco Tool & Screw Corp.
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Pheoll Manufacturing Co.
Reading Screw Co.
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Russell Burdsall & Ward Bolt & Nut Co.
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Seaboard Screw Corp.
Shakeproof Inc.
The Southington Hardware Mfg. Co.
The Steel Company of Canada, Ltd.
Sterling Bolt Co.
Stronghold Screw Products, Inc.
Wales-Beech Corp.
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Phillips Screw Mfrs., c/o Horton-Noyes Co.
1800 Industrial Trust Bldg., Providence, R. I.
Send me the new booklet—"How to Select Recessed Head Screws for Practical Production Driving".

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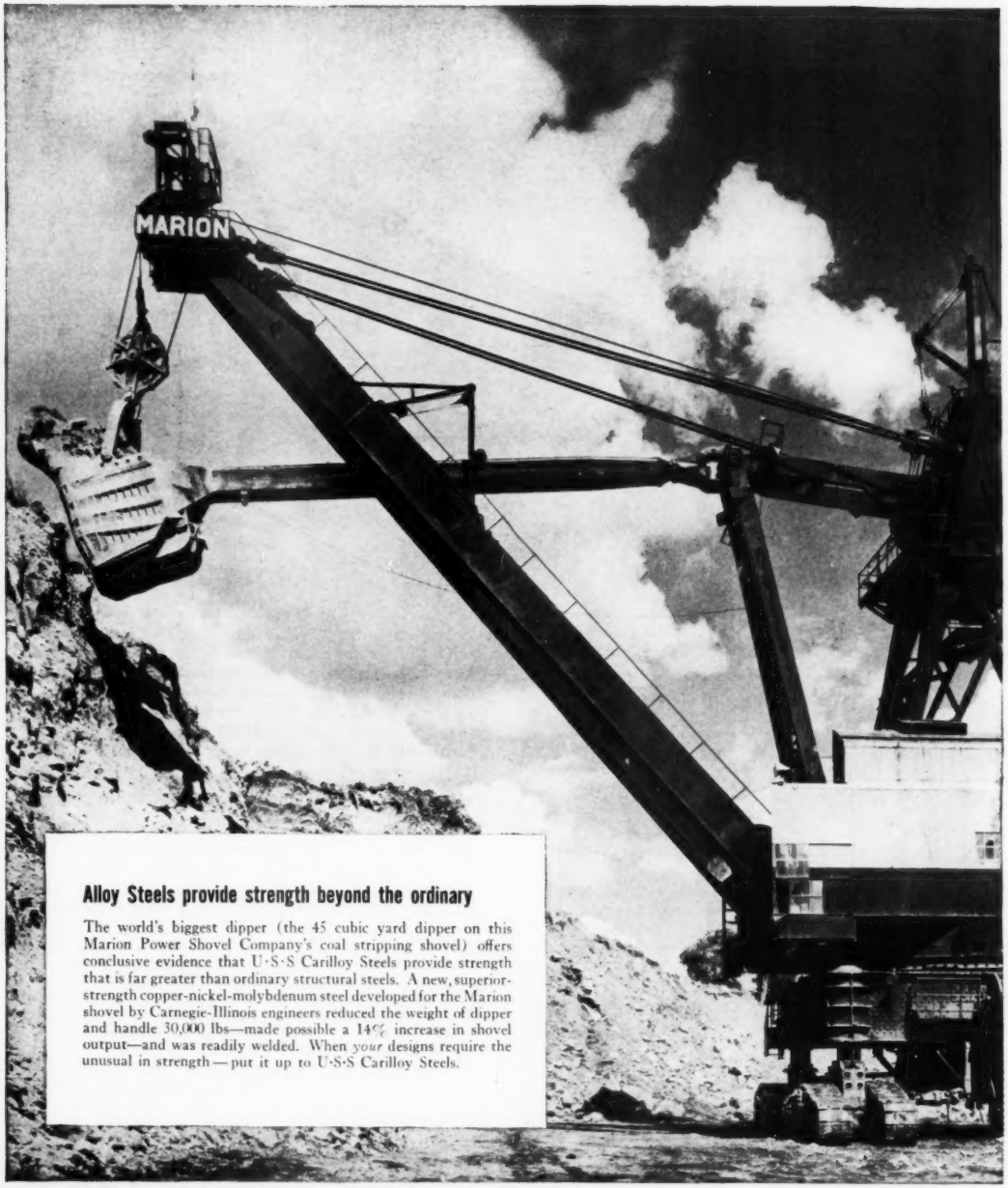
Company PE-49
Address .....

Look at the jobs U·S·S



Alloy Steels provide strength beyond the ordinary

The world's biggest dipper (the 45 cubic yard dipper on this Marion Power Shovel Company's coal stripping shovel) offers conclusive evidence that U·S·S Carilloy Steels provide strength that is far greater than ordinary structural steels. A new, superior-strength copper-nickel-molybdenum steel developed for the Marion shovel by Carnegie-Illinois engineers reduced the weight of dipper and handle 30,000 lbs—made possible a 14% increase in shovel output—and was readily welded. When *your* designs require the unusual in strength — put it up to U·S·S Carilloy Steels.

UNITED STATES STEEL

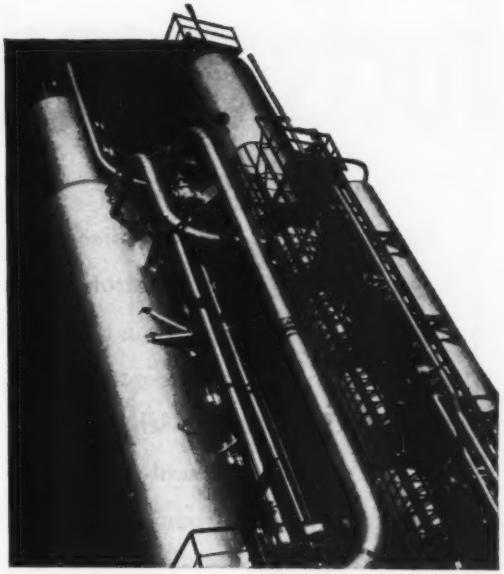
CARILLOY STEELS are doing!

IN THOSE *vital* parts of equipment—where greater strength and toughness are required—where weight reduction or increased resistance to wear, fatigue, and shock is necessary – where it is imperative to withstand high temperatures and pressures—U·S·S Carilloy Steels will meet your requirements efficiently and economically.

For with these special purpose steels, you can obtain practically any combination of desirable properties to exactly fit your product requirements (and your fabricating processes).

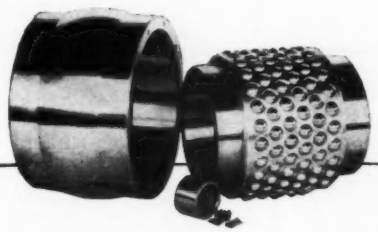
U·S·S Carilloy Steels include Bearing Steels . . . Aircraft Quality Steels . . . Creep Resisting Steels . . . Triple Alloy and Special Analysis Steels, as well as other AISI and SAE Steels. They are available in all grades, in all finishes and treatments, and in the *widest range of forms and sizes available anywhere.* They are produced by either Electric Furnace or Open Hearth process.

These superior alloy steels and the specialized metallurgical and engineering knowledge accumulated in their widespread application are available to help you build greater efficiency, greater permanence and greater sales appeal into your products. We welcome the opportunity to work with you.



Alloy Steels withstand high temperatures

The U·S·S Carilloy Steels recommended for high temperature service have demonstrated high resistance to creep. They maintain high strength at high temperature. They can be heat treated to develop optimum properties. In addition a wide range of types is available to meet the design requirements. If you are designing oil stills or cracking units, pressure tanks, steam turbines, boilers, superheaters, pumps, valves and piping that must operate under high temperature and high pressure—U·S·S Carilloy Steels will do the job.



Alloy Steels meet requirements for precision jobs

In bearings and gears, where precision is a "must," the unvarying uniformity of U·S·S Carilloy Steels is helping designers and manufacturers to meet the most difficult performance standards. These steels are easy to forge, easy to machine and respond consistently to heat treatment. Made to rigid specifications, produced in special Alloy plants, by specialists who make alloy steels and nothing else, these tailor-made steels assure economical fabrication—better performance of products in service.

CARNEGIE-ILLINOIS STEEL CORPORATION
PITTSBURGH AND CHICAGO
COLUMBIA STEEL COMPANY, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
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Company.....
City.....State.....

9-390

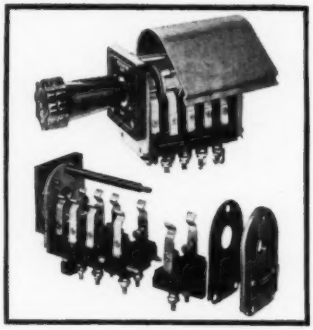
UNITED STATES STEEL

ALLIS-CHALMERS OFFERS EQUIPMENT

Facts about A-C ALLIS-CHALMERS control

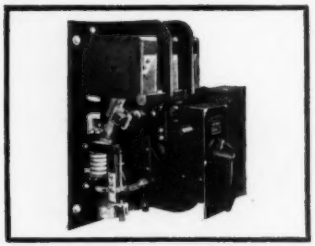
Pictured here is *part* of Allis-Chalmers wide line of switchgear and control devices... being advertised for the first time to designers! Now, you can get high quality control devices from the *same* O.E.M. supplier who offers the widest range of V-belt equipment—Texrope—as well as a-c and d-c motors from ½ hp up. For a choice of over 1600 *industry accepted products*, make your headquarters Allis-Chalmers!

Texrope is an Allis-Chalmers trademark



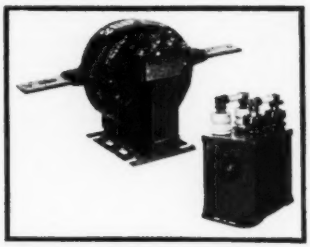
ROTARY CONTROL SWITCHES

Here's a new type rotary control switch especially designed for rough repetitive service. Solid, positive contact motion is achieved through use of square shaft and star-holed contact segments. For ammeter, voltmeter, frequency meter, P. F. meter, circuit breaker, and many other uses. Continuous rating 10 amps, at 600 Volts.



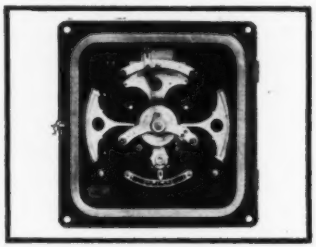
AIR CIRCUIT BREAKERS

Manually or electrically operated for service up to 600 volts a-c. Inverse time series overcurrent trip permits adjustment of overload setting from 100% to 200% of breaker ampere rating, and adjustment of time delay. Also open and enclosed types for individual wall mounting. Type G-25 rated 25,000 RMS amp interrupting capacity; 50 to 600 amp; 600 volts a-c. Type G-50 rated 50,000 RMS amp interrupting capacity; 200 to 1600 amp; 600 volts a-c.



CURRENT AND POTENTIAL TRANSFORMERS

Circular shaped current transformer coils prevent distortion under heavy overcurrents. Flat conductors, accurately formed are hand wrapped with the finest grades of insulating tapes. Construction of potential transformers is compact and strong. Coils are thoroughly impregnated under a vacuum pressure process, insuring a solid coil which is impervious to moisture.



GENERATOR VOLTAGE REGULATORS

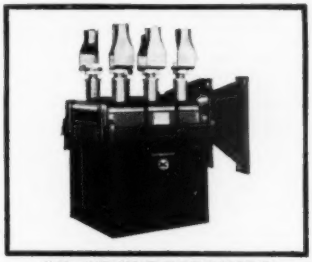
For dependable, smooth, sensitive voltage regulation, you can depend on Allis-Chalmers rocking contact regulators. The principle of *rocking* the field resistance contacts produces smooth, almost frictionless resistance changes. Because of only slight mechanical movement, response is quick with very little bearing wear. Eight type sizes are available for control of a-c and d-c generators of all ratings.

Pioneers in Power and Electrical Equipment From Generation Through Utilization

ALLIS-

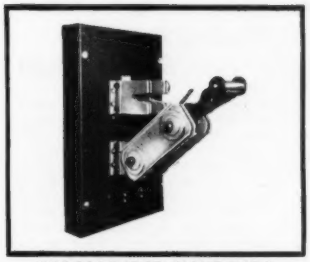
AID TO ELECTRICAL DESIGNERS!

and switchgear devices



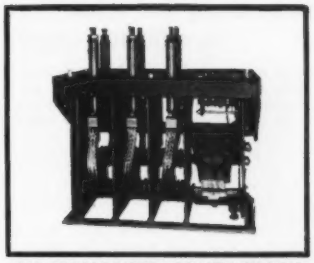
OIL CIRCUIT BREAKERS

Designed for control and protection of generators, feeder circuits, and transformer banks. Available in fully automatic, or non-automatic; manually or electrically operated. Ratings from 15,000 to 50,000 kva interrupting capacity; up to 7500 volts and 1200 amps. Also available are special oil circuit breakers for use in auto transformer circuits of large motor starters; manually operated.



DISCONNECT SWITCHES

Hook stick operated switches rated up to 2000 amp for either panel or framework mounting. Five thousand to 15,000 volts; 600, 1200, and 2000 amps. Also heavy duty clamp type switches for higher load concentrations. Available in panel mounting or unmounted, manual or hook stick operated. Up to 600 volts a-c; 3000 to 6000 amp; 750 volts d-c; 2000 to 10000 amp.



OIL IMMERSED CONTACTORS

Designed for heavy duty motor starting in industrial plants. Contact pitting is reduced by means of improved contact mechanism in which moving contact wipes and rolls with each operation. For use on full and reduced voltage squirrel cage and synchronous motor starters. Maximum ratings 200 amp; 1500 hp at 2300 volts. Interrupting ratings — 10 times full load motor current.

PUSH BUTTON STATIONS

Functional design plus pleasing appearance make these push button stations ideal for almost any industrial use. Available in light duty surface mounting, and heavy duty flush or surface mounting in hundreds of combinations. Ratings up to 600 volts a-c maximum.

All start buttons are encased in shrouds to prevent accidental starting, and locking bars are available so that buttons can be locked in the "stop" position. Delivery from stock.

SEND TODAY

for new 16 page bulletin 2587095 covering Allis-Chalmers switchgear and control devices. It's filled with useful engineering information, including ratings and capacities. Illustrates over 75 control items.

A-C ALLIS-CHALMERS

ALLIS-CHALMERS, 1002A SO. 70 ST.
MILWAUKEE, WIS.

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- Push Button Stations—Catalog Section 6128 ☐
- Generator Voltage Regulators—Catalog Section 2485 plus Bulletins B6143, B6015A, 146035, B6137 ☐
- Current Transformers—Catalog Sections 2801 to 2817 ☐
- Potential Transformers—Catalog Sections 2820 to 2828 ☐
- Disconnect Switches—Catalog Section 2591 ☐
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- Handy Guide for Centrifugal Pumps—Bulletin 52B6059D ☐

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CHALMERS

COPPER ALLOY BULLETIN

PRODUCT IMPROVEMENT EDITION

REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

Prepared Each Month by Bridgeport Brass Co. "Bridgeport" *Headquarters for BRASS, BRONZE and COPPER*

Phosphor Bronze for Longer Life

Overcoming Corrosion in a Mixing Valve

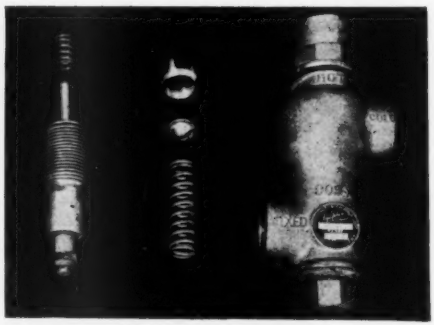
The automatic tempering valve illustrated is used to provide water at any temperature within the range of the thermostat. The mixture of hot and cold water passes over the thermal element. If the mixture is too cold, the bellows gradually contracts and partially closes the cold water port and opens the hot water port wider. If the mixture is too hot, the reverse occurs.

Obviously, the efficiency of the valve depends primarily on the reliable operation of the metal bellows. Bridgeport Phosphor Bronze, which provides an excellent combination of corrosion resistance and resilience under repeated flexing, is excellent for the manufacture of bellows of this type, which may be in constant contact with hot water and other corrosive fluids.

Excellent Corrosion Resistance

Phosphor Bronze is more corrosion resisting than most metals. Steam, hot water, sea water, and similar corrosive liquids and gases used in industrial and processing plants for heating, cooling and refrigeration come in direct, intimate contact with the parts of valves, pressure and temperature gauges and controls made from Phosphor Bronze. Long experience has shown that this metal will stand up under these conditions and give dependable service so necessary for the operation of automatic instruments and controls.

From an engineering standpoint, only the best available metals should be used since the function of the instrument or control depends upon the action of the component — bellows, diaphragms, Bourdon tubing, springs, or electrical and mechanical contacts.



Bellows for Automatic Tempering Valve made of Bridgeport Phosphor Bronze — Courtesy Fulton-Sylphon Division, Robertshaw-Fulton Controls Co., Knoxville, Tenn.

Vacuum Cleaner Switch— Wanted Reliable Spring Action

Contact springs in the vacuum cleaner motor switch illustrated are a good example of parts which are small and insignificant in appearance, but vital to the operation of the equipment. This motor switch is manufactured by Electrolux Corporation, Old Greenwich, Connecticut. The springs made from Bridgeport's Phosphor Bronze must maintain constant pressure and provide dependable contact at all times.

Motor switch connector terminals made from Bridgeport's Phosphor Bronze—Courtesy Electrolux Corporation, Old Greenwich, Connecticut.

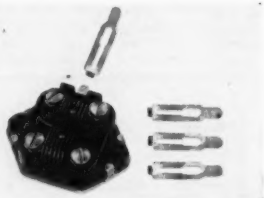
High fatigue resistance and dependable spring properties are developed in Bridgeport's Phosphor Bronze through close laboratory control of composition and careful processing in the mill with powerful modern equipment.

Thermostat Reset Lever— Dependable Spring Quality

Safety in operating electrical and mechanical equipment often depends upon the reliability of a few tiny spring parts. Thermo-O-Disc Protective Thermostat employs Phosphor Bronze for the reset lever because of fine spring properties and dependability.

Phosphor Bronze provides an excellent combination of properties for electrical and mechanical spring applications. Its resilience and high fatigue resistance mean good spring action and dependability through many thousands of flexing cycles. Its high corrosion resistance reduces failure from the attack of corrosive atmospheres. Phosphor Bronze is also unusually tough and resistant to wear and abrasion, insuring continued good mechanical and electrical contact.

The unique properties of phosphor bronze depend not only on alloy composition but also upon improved melting practise, casting techniques and processing methods.



Thermo-O-Disc Protective Thermostat employs reset lever made of Bridgeport's Improved Phosphor Bronze. Courtesy Therm-O-Disc, Inc., Mansfield, Ohio.

Other Applications

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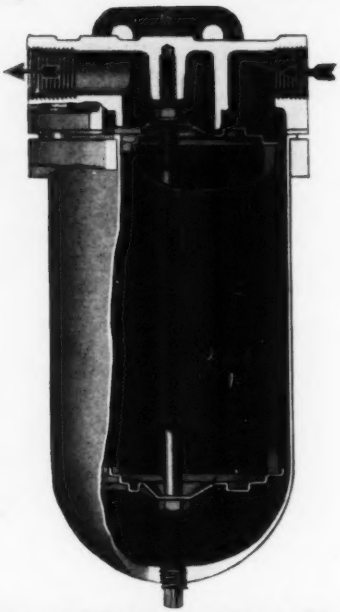

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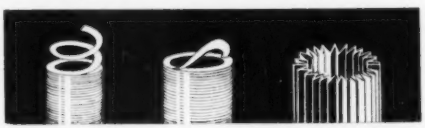

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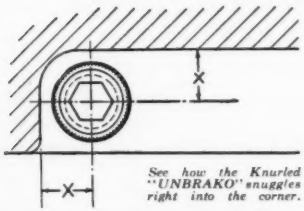
Knurling of Socket Screws originated with "Unbrako" in 1934.

for compact designs . . . space and weight saving . . . faster assembly

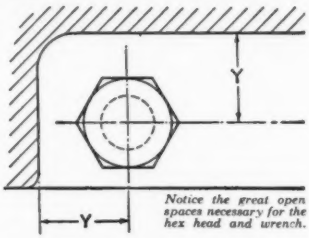
KNURLING (an exclusive "UNBRAKO" feature) on the *head* of the "UNBRAKO" Socket Cap Screw speeds assembly. KNURLING on the *threads* or *points* of our patented "UNBRAKO" Socket Set Screw provides self-locking—"they positively won't shake loose!" In fact, almost any set screw application can be locked with our patented "UNBRAKO." Furthermore, internal wrenching promotes compact design—saves space, weight and material, reduces costs.

When next you need screw products, remember, "It pays to specify and insist on "UNBRAKO!"

Write for the name and address of your nearest "UNBRAKO" Industrial Distributor and your copy of the "UNBRAKO" Catalog.



See how the Knurled "UNBRAKO" snuggles right into the corner.



Notice the great open spaces necessary for the hex head and wrench.

Pat'd and Pats. Pend.

The "UNBRAKO" Socket Set Screw with Knurled Cup Point positively will not shake loose, regardless of the most chattering vibration.

Pat'd

The "UNBRAKO" Self-Locking Socket Set Screw with Knurled Thread for flat, full-dog, half-dog, cone, oval point and for use on hardened shafts. "It won't shake loose!"

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Kits: Pats. Pend.

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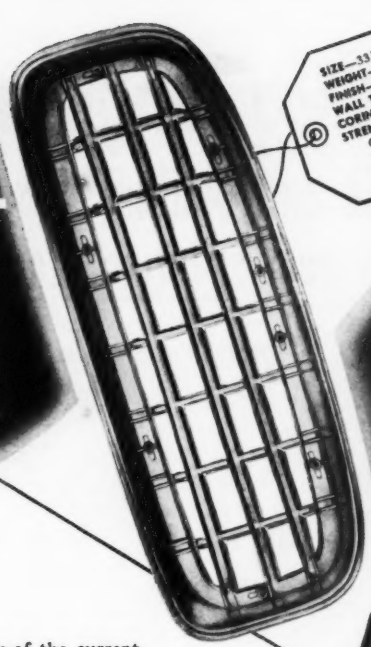
massive appearance- through *clever coring*


SIZE—33½" x 13⅛"
WEIGHT—12¾ lb.
FINISH—Chromium plated
WALL THICKNESS OF THE RIBS—.070"
CORING—All grille openings cored
STRENGTH OF THE ALLOY—
Over 40,000 lbs. / sq. in. tensile
Over 40 ft. lbs. impact—½" bar
(Strength values determined on test bars)

another successful product designed for ZINC DIE CASTING

The radiator grilles of many of the current cars are built-up assemblies of die cast parts, but this particular design—for the 1949 Nash Airflyte— is a one-piece zinc die casting. Not only does a die casting meet the physical and mechanical requirements of this design (see tag on casting), but it consumes a minimum amount of metal.

The grille casting is shown from the rear to reveal the clever coring of the horizontal and vertical ribs. The ribs thus appear to be solid sections when viewed from the front, but the coring effects a considerable saving in both metal and weight—with no sacrifice of strength! This grille is tailored to fit the car instead of vice-versa and its inherent dimensional accuracy greatly reduces assembly problems. Note, also, the cast assembly bosses.

This is just one of many successful applications for zinc die castings in the automotive industry. Typical applications in other fields of manufacture will be covered in future advertisements in these pages.

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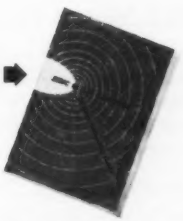

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FOR DIE CASTING ALLOYS

THE NEW JERSEY ZINC COMPANY, 160 Front St., New York 7, N. Y.

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TO MEET YOUR MOST EXACTING REQUIREMENTS . . .

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are made of 99.95% pure tungsten, thus assuring the highest melting point of any contact material . . . a hard, bright, oxidation-resisting finish, high density, maximum life, low vapor pressure at elevated temperatures, high strength and arc-resisting properties.

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Wilco tungsten contact assemblies are assembled to springs, blades, brackets, arms and screws (brazed, riveted, welded, spun) . . . conforming in size, shape and material to manufacturers' individual requirements . . . assuring the superfine quality found in all other WILCO contact materials.

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CONSULT OUR ENGINEERING DEPARTMENT . . . A representative of the WILCO Engineering Department will gladly help develop the proper application of WILCO materials to your products.

WILCO PRODUCTS INCLUDE: THERMOSTATIC BIMETALS: All temperature ranges, deflection rates and electrical resistivities. ELECTRICAL CONTACTS: Silver, Platinum, Tungsten, Alloys, Sintered Powder Metal. SILVER CLAD STEEL: For industrial use. NI-SPAN C* Constant Modulus alloy: JACKETED WIRE: Silver on Steel, Copper, Invar and many other combinations. SPECIAL ALLOYS: Including high conductivity, high strength Copper Alloys. ROLLED GOLD PLATE AND GOLD FILLED WIRE.

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Prices Must Come Down

GALIIEO was brought before the king and flogged and tortured until he recanted his announcement that the earth rotated and revolved around the sun. After he had said, "I was wrong; the earth stands still", and he was being lead away bleeding and in great pain, he muttered, "It moves anyhow!"

Hopes, fears and wishful thinking are still battling stark reality, and probably always will as long as humans are what they are. Men will state only those facts and figures that bear out what they wish to prove. There is always the temptation to quote statements out of context, to drown a fact in a sea of unrelated figures, to gloss over actualities with a coating of sugar.

For these reasons, for one who is not expert in the intricacies of economics it is difficult to make head or tail out of the deluge of contradicting figures, opposing opinions and jockeying that is now going on with reference to economic prognostications. Engineers who have an abiding faith in the axiom that two plus two make four, get terribly confused. One government department issues figures to show that savings are at an all time high. Then the government liberalizes the terms for installment buying because people do not have enough savings to meet the required down payment.

Almost 4,000,000 people are reported out of work but this is glossed over with the statement that employment is higher than ever. Department stores' sales are reported to be about 10 percent off, but Easter comes late this year. Reported plant shut downs are explained as being seasonal.

It is natural that engineers cannot understand economists, and vice versa. Also, only the optimist gets a big hand; no one has ever heard an audience applaud a man who told truths that hurt. Nor have crepe hangers ever contributed materially to the progress of man. But it is also true that only those who are prepared will be able to partake of the feast while the ones who are not ready stay hungry.

Regardless of claims to the contrary, prices of products and machinery are coming down. The sellers' market has vanished and in the future the buyers-market price tags will rule. Smart engineers and progressive companies know it well and for months have been redesigning their products to reduce costs. Only through the development of low-cost designs is it possible to meet the demand for ever higher standards of living, for lower priced goods without proportional wage cuts and for full employment. Following such redesign must come of course the use of the most efficient manufacturing machinery and equipment obtainable, the best managerial operation, and improved marketing distribution.

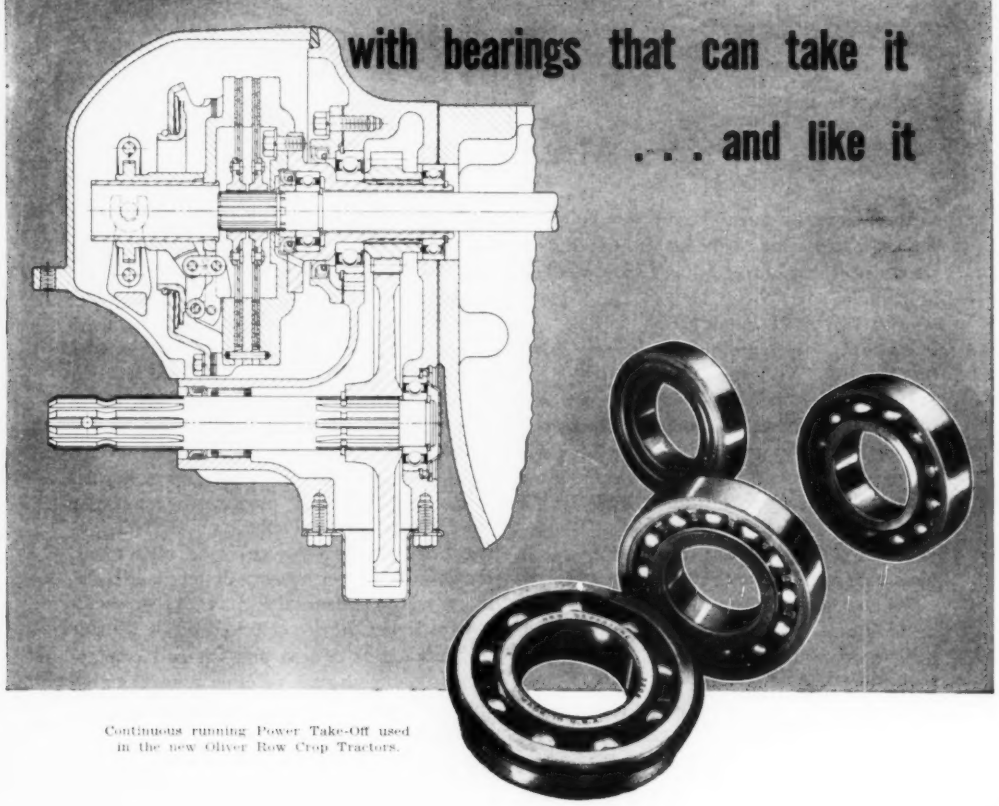
It is pointless to argue when and how severe the coming deflation will be. Failure of industry to make available lower priced goods will hasten and deepen the recession, deflation or what you may call it. Only if industry concentrates on designing for lower costs will there be a minimum disturbance to wages, employment and profits. How hundreds of companies are doing it will be told in the June number of PRODUCT ENGINEERING.

G. F. Yoderholt

Designed for continuous running

with bearings that can take it

. . . and like it



Continuous running Power Take-Off used in the new Oliver Row Crop Tractors.

When shafts and gears are held rigidly in perfect alignment, yet with practically no frictional losses in the supporting bearings—that means *full* power at the take-off for useful work.

And the permanently accurate support achieved with New Departure Ball Bearings means the lowest possible wear rate in gears and related parts. For long life and full efficiency in farm machinery, it always pays to specify New Departure ball bearings.

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BALL BEARINGS

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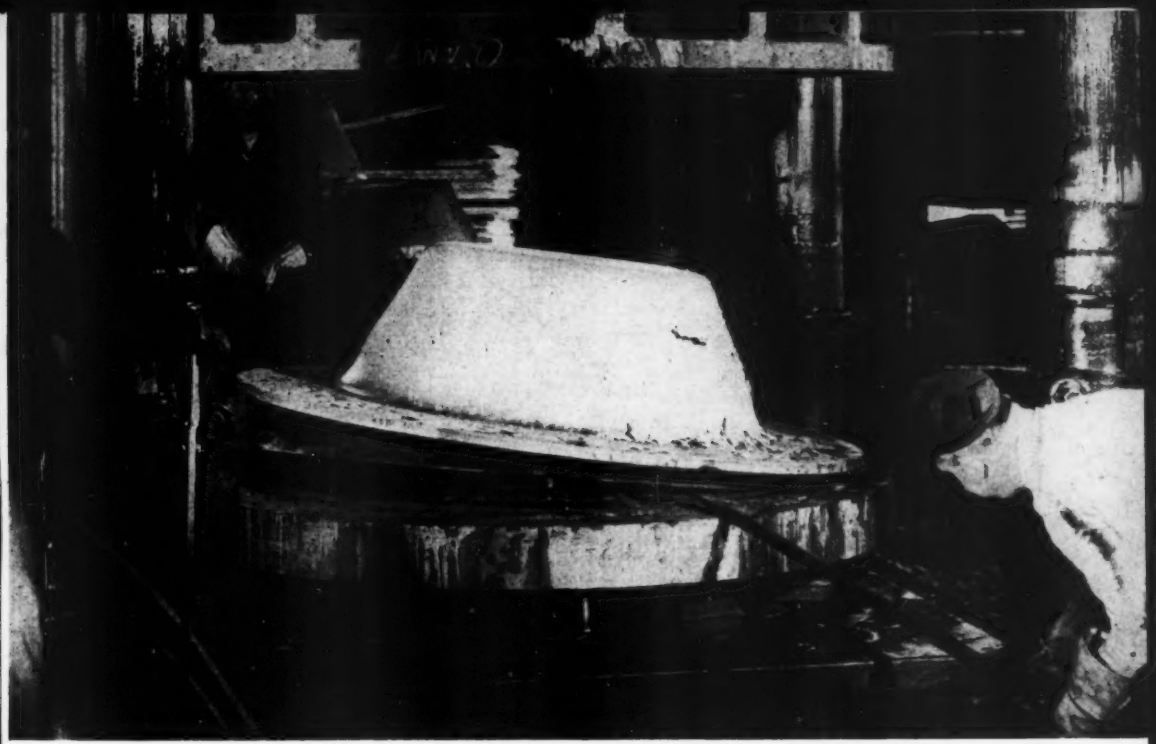


HOT PRESSING a head shape. Heads are also spun as shown on the cover, when size, material and economy so dictate.

Using Head Shapes To Cut Costs

Tank heads, or head shapes, offer intriguing possibilities for simpler construction of machine elements wherever all or a portion of the element is in the form of a surface of revolution.

HERBERT A. OTTEY
Engineer, Flanged Products
Lukens Steel Company

STEEL HEADS are commonly thought of as structural parts forming the ends of storage tanks, pressure vessels and production equipment in the chemical and power industries. Considerably less well known are applications in the machinery field, where head shapes are being incorporated into designs because they combine many economic and mechanical advantages.

Head shapes were first developed as ends of cylindrical boilers. Since operating pressures were then very low, the flat, flanged circular disk was adequate for ends, or heads. As higher pressures came into use, it was necessary to dish the head to a spherical surface. Because of the tooling problem, few firms could afford to make their own limited requirements. Therefore, some manufacturers came to specialize in the production of head shapes.

Ultimately, various types of standard head shapes were developed. Some of these are shown in Fig. 1. Hemispherical, elliptical, conical, dish-and-flared, flanged-only heads and other shapes having modifications in the depth of dish and in such features as flue holes and pipe connections are commercially available.

By ingenious combinations of types or parts of head shapes with other structural elements of a machine, the designer often can achieve significant cost reductions and mechanical improvements.

Advantages of Head Shapes

First, head shapes are available in stock sizes with uniform dimensions.

1. By incorporating a prefabricated shape in a design, it may be possible to save considerable production time. The shop starts with a semi-finished product, rather than a raw material.

2. Because head shapes can be supplied by outside producers, and often from stock, less inventory need be carried.

3. The designer's shop may be able to avoid the purchase or use of equipment normally required to fabricate that part of the product. Use of a semi-finished product reduces the equipment needed.

Other advantages accrue to the user of head shapes and are inherent in the product:

1. Since head shapes are spun or pressed from steel plates, they have a dense homogenous structure inherently free from sand pockets and blow holes.

2. Uniform structural strength is assured.

3. Steel plate construction often results in a lighter construction than a casting or combination of casting and built-up structure, without any sacrifice in strength or rigidity.

4. Dimensions are uniform to fairly

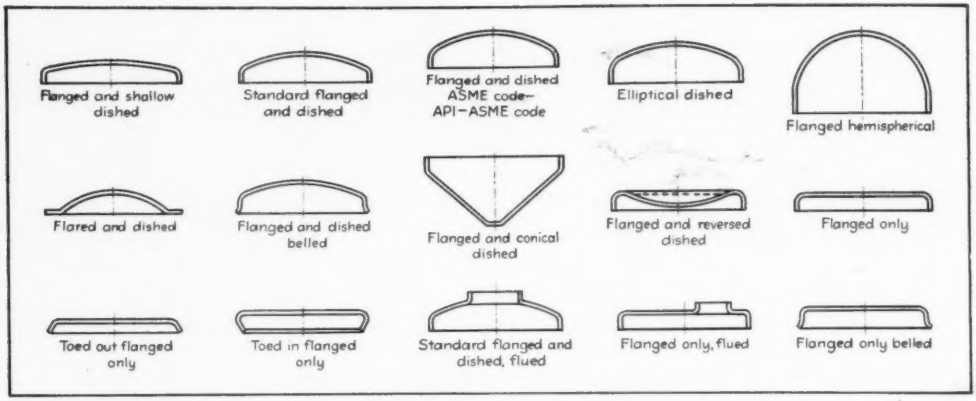


Fig. 1—Head shapes are made in more than simple spherical forms. Variations in flanging and dishing are standardized and enable heads to be adapted to many mechanical functions. Because of the flexibility of the spinning process, the degree of dishing and flanging usually can be changed quite economically to suit a particular design requirement.

close tolerances, and, therefore, by proper design, machining time can be either eliminated or greatly minimized. The accuracy of dimensions also facilitates assembly.

5. Since large, one-piece parts are used, fewer joints or seams are required. Riveting or welding expense and time thus are minimized.

6. A fairly smooth, well-finished surface is inherent in pressed or spun plate head shapes.

7. If stock head shapes are used, they can be readily replaced when worn out.

8. Often the cost is lower than when using other materials and techniques. These are good reasons for using head shapes providing that they can be incorporated in the design. Therefore the problem is: how can head shapes be used most effectively?

Designing for Head Shapes

A little reflection will show that, basically, a head shape is a surface of revolution. Any portion of a machine which comprises such a surface, or which might conceivably be designed to be a surface of revolution, is a potential spot for a head shape.

The designer has available a wide choice of circular shapes of various profiles. These suggest use as bottoms of vessels or ends of cylinders; as covers or housings for circular components of a machine, such as gears, or as circular structural elements, such as bases, pedestals and frames. But it is not mandatory to use the entire head shape. Parts or sections of heads can be employed effectively. Basic modifications are:

1. Removing material by flame cutting—
   - (a) to make holes or remove portions of the shape.
   - (b) across a diameter, to get semicircular members.
   - (c) across a chord, as required.
   - (d) along radii, to get or to remove a sector.
   - (e) on a small circle, to get spherical segments or to get rings for rims and flanges.
2. Adding material by welding—
   - (a) to plate. Example: Weld halves of a head to a rectangular plate to form a gear cover.
   - (b) to other heads. Example: Weld two elliptical dished heads together to form a concrete mixer drum.
   - (c) to structural shapes. Example: Weld to the end of seamless tubing to form a pedestal.
   - (d) to attach a mount or guide. Example: Weld a bearing mount to a flue hole in a head shape to form a bracket.
3. Combinations of (1) and (2).

Many examples are shown in the illustrations or described in Table I. With the above modifications in mind, some fundamental applications are:

1. As integral ends of cylindrical structures. This is the obvious use for head shapes. Flanged only, flanged and dished, flanged and dished heads,

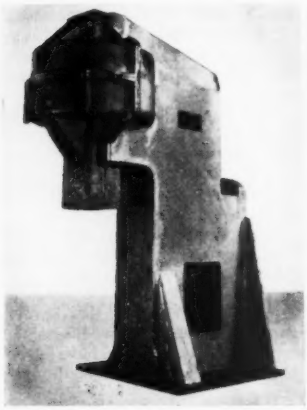


Fig. 4—A 22 in. inverted rod block frame for wire drawing machines. Two flanged only heads are used at the top; these heads have a 34 in. OD, 9¾ in. flange, ¾ in. thickness, and 1 in. corner radius.

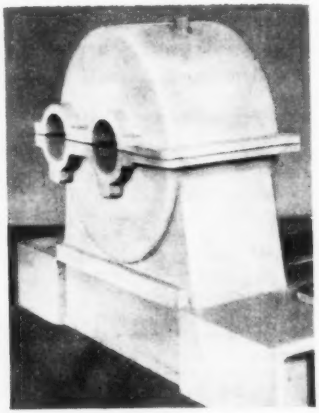


Fig. 5—Welded steel bed plate and gear case fabricated from two flanged only heads. The heads measure approximately 36 in. OD, ¾ in. in thickness and 3 in. in straight flange. Total weight is 3,250 lb.

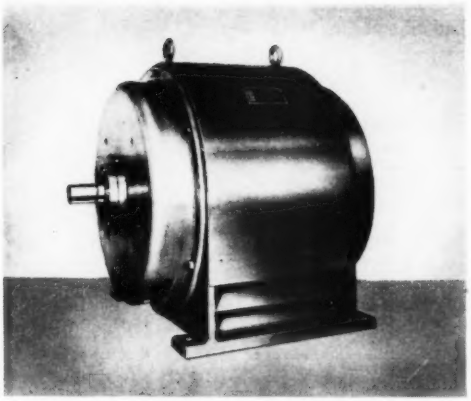


Fig. 2—Large end shields were made from modified heads. Flanges were welded to the 3 ft dia head and a bearing mount welded over a center hole to support the armature shaft.

Fig. 3—The builder of this tire molding press avoided any heavy forming operations in his plant by standardizing on a head shape for the top of the circularly shaped steam box.

or elliptical dished heads are welded to form the ends of machines. Joining by riveting the head shape is equally practical in some designs. Either deeper or shallower dished shapes, with or without flanges, can be selected to obtain the desired conformation.

2. As removable covers for various type openings. Mechanical functions such as supporting shafts, bearing mounts and other parts, can be accomplished simultaneously.

In the large squirrel cage motor, Fig. 2, the end shields are standard flanged-only heads, about 3 ft OD, which have been adapted for bearing mounts.

3. As circular structural elements.

A complete head shape is incorporated as part of the machines shown in Figs. 3 and 4. The tire press, Fig. 3, uses the head shape as the top of the steam box. Applications are not limited to large heavy parts. Small head shapes have been used as the bases of a floor type fan.

4. In combinations of parts or of entire head shapes.

This offers many unique possibilities. The gear housing, Fig. 5, was formed by using two head shapes, cutting them along a diameter and welding on flanges.

5. Modifying by cutting out holes or segments to adapt the head shape for various mechanical functions.

For example, cast iron hoods are acceptable as covers for grinding wheels with speeds up to 7,000 surface fpm, according to the ASA code. However, some users have demanded steel guards regardless of the surface speed. One grinding machine company found that a simple solution was to use a flanged-only steel head, Fig. 6, and to cut out a section for working space.

Similarly, by making holes for ventilation and by welding a circular thrust bearing to the flue hole, an elliptical head was used as the cover of the vertical waterwheel driven generator, shown in Fig. 7. The design was more compact because the separate upper thrust bearing bracket, which is

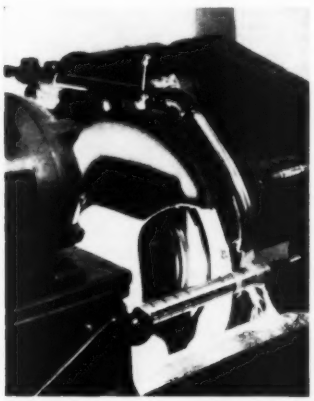


Fig. 6—Cover of the grinding wheel is made from a flanged only head. The steel hood, or cover, is less likely to shatter than a cast iron hood in event of wheel breakage at high speed.

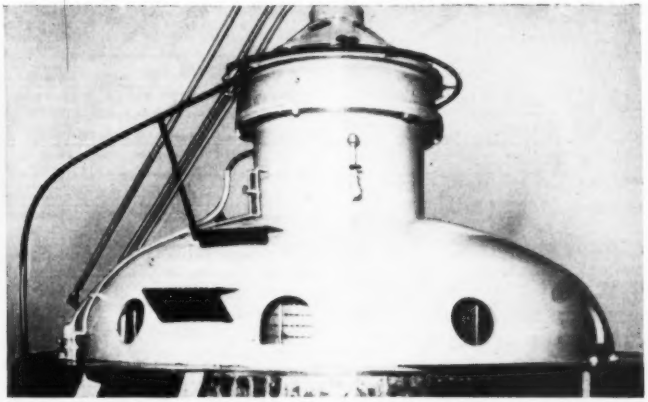


Fig. 7—Elliptical head used in a 1,000 kva vertical waterwheel-drive generator. The head, 138 in. ID, 1¼ in. nominal straight flange forms the cover in conjunction with a circular thrust bearing welded to the head. This novel construction eliminates the separate upper bearing bracket which usually is mounted above the stator frame, and results in a more compact unit with lower production costs.

Table I—Applications of Head Shapes in Machinery

Part	Kind of Machine	Type of Head Shape	How Constructed	Approximate Size
Brake Rims	Oil well drilling rigs	Flanged-Only	Drum pressed by Lukens. Machined heat treated and water jack installed by rig manufacturer	5 ft 4-1/2 in. OD x 1-1/2 in.
Containers and Bases of Containers	Lead drossing pots	Elliptical	Skirt welded to flange	122 in. OD x 1 in.
	Evaporating pans	Flanged-Dished Hemispherical and Flanged-Dished and Flared	Flange attached by customer	48 in. to 60 in. OD 3/8 in. and heavier gage
	Open hearth ladles	Flanged-Only, Toed-out flange	Heads welded to sides	84 in. x 2 in.
	Cooking kettles	Hemispherical	Formed head, mounted on legs	60 in. x 1/4 in.
	Dough mixers	Hemispherical	Formed head, mounted on table	24 in. x 1/2 in.
	Aircraft engine storage	Flanged-Dished	Head attached to shell with angle ring	58-1/4 in. OD x 3/16 in.
	Pressure tank for orchard sprayer	Flanged-Dished	Formed head, with pump attached to shell	51 in. OD x 3/16 in.
	Centrifugal	Flanged and reverse dished	Formed head used as bottom of basket with welded sides	80 in. x 5/8 in.
	Ladles	Flanged-Only Flared out	Formed head used as bottom of ladle	71-1/2 in. OD x 7/8 in. Min.
Covers and Housings for	Gears	Dished-Only	Head, forms web and gear welding thereto, rim and hub after which teeth are cut	24 in. x 3/4 in.
	Clutch on amphibian vessel	Flanged-Only	Center cut out for shaft Holes drilled to mount	24 in. x 5/16 in.
	Turbines	Flanged-Only	Formed head welded to casing	234 in. x 1-1/4 in.
	Grinders	Flanged-Only	Head cut away and two pieces welded together for one unit	33-3/8 in. x 3/8 in.
	Tire presses	ASME Flanged-Dished	Holes machined cut after head formed	42 in. OD x 3/4 in.
	Road rollers	Flanged-Only	One-quarter segments cut to round off sharp corners	30 in. OD x 1/4 in.
	Pressure food cooker	Flared and dished	Formed and flue two openings Center hole for rotary shaft	66 in. x 3/4 in.
Windbox Support	Pulverizer	Flared-Dished	Center cut. Head used in bottom gravity feed	120 in. OD x 1 in.
End Shields and Bearing Supports	Electric motors	Flanged-Only	Center hole cut for shafts	48 in. x 1/2 in.
Bases	Pans	Dished and flared	Head attached upright position	20 in. x 3/16 in.
	Tables	Dished and flared	Head attached center support	18 in. x 3/16 in.
Expansion Joints	Steam pipes Rotary kilns Heat exchanger	Flanged-Only Flued	Two heads welded flange-to-flange	104 in. x 3/8 in.
Hubs	Drier rolls	Flanged and reversed dished	Formed head reinforced with ribs mounted to shaft	24 to 36 in. x 3/4 in.
	Road rollers	Flanged-Only	Head with hub attached roller shell	30 in. x 9/16 in.
	Agriculture rollers	Flanged-Only	Head with hub attached to pipe	18 in. x 1/4 in.
Drums	Concrete mixers	Flanged-Only with rim	Center hole cut out, rim forms rotating track	62 in. x 1/4 in.
Gongs	Burglar alarms Fire alarms	Flanged-Only	Formed head attached to hammer striker	14 in. x 3/16 in.
Ladder turntable bases	Fire trucks	Flanged-Only	Formed head attached to rotating base	22 in. x 1/2 in.
Universal Joints	Bailey Bridge bases	Flanged-Only and Flanged-Dished	Heads stiffened with internal ribs. Dished head mounted on flanged head to support footing	51 in. and 36 in. x 1/4 in.
Fifth Wheel	Farm wagons	Flanged-Only	Center cut out and head fitted to wagon bed	18 in. x 3/16 in.
Pedestal for Spring Seat	Railroad car	Flanged-Only	Two sides cut out with center hole drilled	9-1/4 in. x 1/4 in.
Discharge Cone	Portable sand blaster	Flanged and conically dished	Attached bottom of unit gravity feed, also partitions	24 in. x 3/8 in.
Pontoon Ends	Dredger	Flanged and conically dished	Head attached shell forming pontoon pipe	56 in. x 5/16 in.
Fan Funnel	Diesel engine	Conical	Mounted vertical aid in air cooling engine	80 in. x 3/16 in.
Cap and Pile Point	Concrete and wood piles	Flanged-Only Flanged and conically dished	Formed-Only	14 in. x 7/16 in.
Ends, Sump and Shredder	Paper pulper	Flanged and dished	Ends of tank, also edges, saw tooth cut for shredding paper	30 to 72 in. x 5/16 in.
Vulcanizing Chamber	Tire recapper			
Rotary Tables	Canning machinery Feed unit Auto turn table	Flanged-Only Flanged-Only	Flanged and flued Head mounted on motor driven by rim display room, auto dealers	70 in. OD x 9/16 in. 16-7/8 in. x 10 in. 48 in. x 3/16 in.
Core Collar	Coil wrapping	Flanged-Only	Holes for wire rope and coca matting cut in formed head	8 in. x 1/2 in.
Mooring Bit	Ship installation		Two holes cut to mount upright posts	22 in. x 66 in. x 3/4 in.
Bulkheads	Penstock	Hemispherical	Ten segments welded by customer	17 ft 10-1/4 in. x 3/4 in.
Gear Webs		Straight sided cones		79 in. OD at large end; 18 in. OD at small end. (5/8 in. gauge)

Fig. 8—Pre-heater drum fabricated to operate at 175 psi under provision of paragraph U-69 of the ASME unfired pressure vessel code.

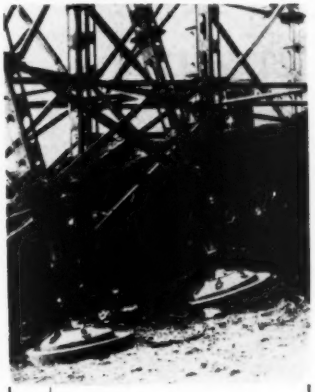


Fig. 9—Unique universal joint for this Bailey bridge base pad is made from heads according to the sketch.

usually mounted above the stator frame, was not required.

6. Compound construction by welding head shapes and parts of head shapes to plate.

Using a reverse dished head and welding triangular braces to the axle in the manner shown in Fig. 8, a simple and strong hub construction was provided for a pre-heater drum. Expansion joints can be made by welding together flanged-only heads.

A unique universal joint and base plate or pad for a Bailey bridge was made from several heads. Construction can be seen from the sketch in Fig. 9.

A heavy rim, Fig. 10 was made for the housing on a ball-bearing pulverizer by cutting out the center of a flared and dished head pressed to the desired dimensions. The original design called for a four-segmented pressed ring to give the needed bevel and another four-segmented ring for the flare. The standard head shape was more easily adapted, with an increase in uniformity and fabrication cost saving of approximately 20 percent over the built-up, welded design.

These examples illustrate only a few of the ways in which circular preformed shapes can be incorporated into design. Table I includes a more comprehensive list of ways in which head shapes have been used.

Design Data

Since head shapes were developed initially to satisfy the Boiler Code requirements, their strength and dimensions were standardized. Heads not included in the Code are made to manufacturer's standards. Both ASME code and standard heads are carried in stock because of large demand. The designer will have to consider the number of heads required and the equipment available to produce them, before deciding whether it is best to manufacture or buy the heads.

There are two methods of making heads, spinning and pressing. For pressed heads, it is necessary to have presses of adequate capacity with dies of the desired shape and dimensions. The expense for special dies is justified only when the demand for any one size is rather large. For spinning, spinning equipment must be available, of course. Otherwise, it is probably more economical to purchase heads from a supplier who has the necessary equipment on hand for efficient production.

Pressed heads have the advantages of being more accurate, more uniform, and undergoing less thinning of the metal during forming than spun heads. This permits less allowance in the flat blank thickness. Also, production is faster and the cost is lower when the quantity warrants the use of pressing.

Pressing is preferable for forming some alloys such as stainless steel, which does not flow readily under the rollers of the spinning machine. However, both cold and hot pressed heads require a closer gage tolerance in the flat rolled metal because of die clearance.

With spun heads no special gage tolerance is necessary. Another advantage of spinning is that gage can be varied without any trouble, while a pressing die made for a specific thickness cannot be used for a different gage without changing the size of either the male or female die.

Spun heads are more economical than pressed heads when only a few units are required. They can be produced in any fractional increment of diameter between the smallest and largest available, usually without cost for dies. At present, heads are spun from about 12 in. to 20 ft 6 in. in diameter; or pressed from about 4 in. to 108 in. in diameter.

Almost any kind of steel, either clad or solid, can be spun or pressed, either hot or cold. Many nonferrous metals and their alloys can be successfully spun or pressed. There is almost no common material that cannot be formed into a head shape.

Gages from small fractions of an inch up to $6\frac{1}{2}$ in. have been pressed or spun. The blank diameters required vary with the nature of the head, the curvature, and the gage. Formulas for their computation depend upon the above variables and the production technique. These formulas, and other data can be obtained from the manual "Flanging and Pressing," published by Lukens Steel Company.

When the range of materials, gages, sizes and shapes available is considered, limitations are few. Of course it is not suggested that all designs can or should use head shapes. Primary point is that head shape adaptations are effective and economical ways of simplifying construction. Cost savings and applications are usually in direct proportion to the ingenuity of the designer.

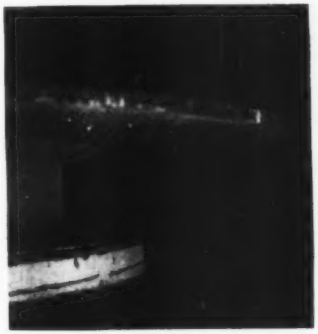
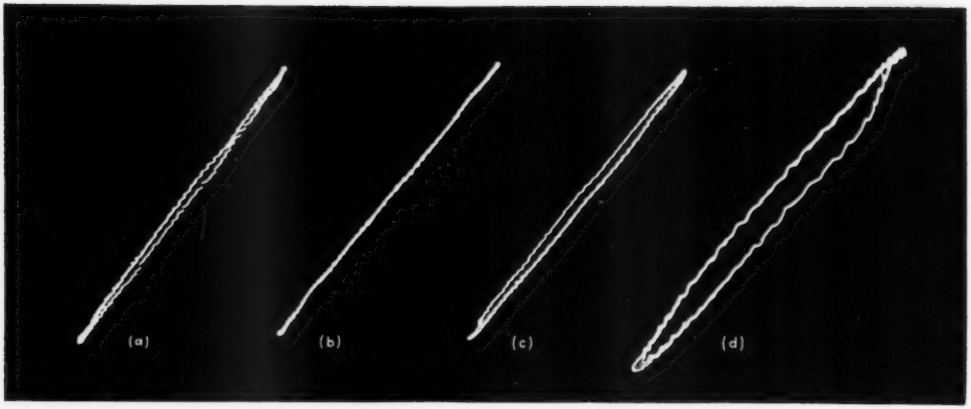


Fig. 10—The lower rim of the housing of this ball-bearing pulverizer, which supports the evacuation baffle-plates, shows economy effected by the use of a head shape. The head application permitted savings of more than 300 in. of expensive weld. A flared and dished head was pressed to the desired dimensions and the excess material cut away forming a rim.



VERTICAL SHEAR hysteresis loops as photographed from a cathode ray screen. They show comparative damping qualities of (a) natural rubber, (b) neoprene, (c) neoprene of higher hysteresis and (d) GR-S rubber. The areas represent energy dissipated.

Vibration Control of Engines

- Control of linear vibration by correct mounting.
- Method for comparing the performance of different materials as used in the actual mount.
- Effect of natural rubber on damping efficiency.

LLOYD E. MULLER
Staff Engineer, Buick Motor Division

VIBRATION can be controlled if the three essential factors affecting vibration are given their proper consideration and are used properly. These three control methods are:

1. Reduce the exciting force if possible.
2. Isolate by the proper resonant frequency.
3. Provide damping to dissipate energy.

Free or Resonant Vibration

The mathematical expression for the frequency per minute of a simple form, such as a weight hanging on a spring, is

$$f = \frac{60}{2\pi}\sqrt{\frac{KG}{W}} \qquad (1)$$

where

K = rate of the spring, lb per in.
G = acceleration of gravity, 386 in. per sec per sec
W = weight of suspended mass, lb

A practical application of the above is a single cylinder gasoline engine mounted on a spring as shown in Fig. 1. If the spring has a rate of 35,450 lb per in. and the engine weighs 386 lb, the resonant frequency of the system will be 1,800 cpm. If the engine is run at this speed a violent shaking will result. The starting and stopping of the reciprocating parts such as the piston are considered to be the exciting forces. Similarly, an out of balance armature will cause an electric motor to shake on its mounts, or a poorly balanced propeller will vibrate an airplane engine. The unbalance of an automobile tire will produce wheel tramp.

The corrective measure for the trouble encountered with the armature, propeller or automobile tire is to balance them by removing or adding weight. The corrective action for the engine is not so apparent.

If the speed of the eccentric, shown in the spring-weight system in Fig. 2, is gradually increased from zero to four times the resonant frequency, and the displacement of the weight is measured at the various speeds of the eccentric, a curve shown in Fig. 3 will be obtained. It will be noted that the movement of the weight is equal to or greater than the movement of the eccentric until the speed of the eccentric is greater than 1.414 times the resonant frequency of the system. To decrease the engine's amplitude to a practical quantity, the stiffness of the spring, Fig. 1, must be reduced until the resonant frequency of the engine on its mounts is about $\frac{1}{3}$ of its running speed, or 600 cycles per minute.

Forced Vibration

A common question is "Why go to the trouble of installing springs or rubber mounts when the engine can be bolted to its base and avoid this resonant vibration trouble?" This brings up the problem of forced vibration.

If the engine is attached solidly to a structure or vehicle chassis, it will force vibration into that structure and create an unpleasant shaking and noise. If suitable mounts are used, these disturbances can be controlled to a point where they are not objectionable. The magnitude of the force transmitted through the mount compared to original force is called the transmissibility of the mount. This is expressed mathematically as follows:

$$T = \frac{1}{\left(\frac{F}{f_N}\right)^2 - 1} \qquad (2)$$

where F = disturbing frequency, cpm
f_N = natural frequency of mounted assembly, cpm

If the mounts, Fig. 2, are used with the gasoline engine, Fig. 1, the force going into the surrounding structure would be shown by the calculation:

$$T = \frac{1}{\left(\frac{1,800}{600}\right)^2 - 1} = \frac{1}{8}$$

Therefore, by using mounts that give a resonant frequency of 600 cpm or $\frac{1}{3}$ of the operating frequency, the vibratory force going into the support-

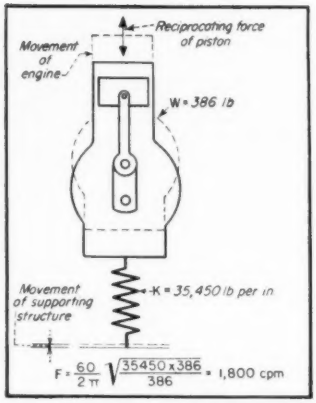

Reciprocating force of piston
Movement of engine
W = 386 lb
Movement of supporting structure
K = 35,450 lb per in
F = 60/2π √(35450 x 386/386) = 1,800 cpm

Fig. 1—Application of formula 1 to a single cylinder engine vibration problem.

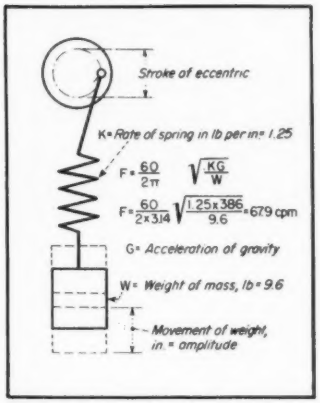

Stroke of eccentric
K = Rate of spring in lb per in = 1.25
F = 60/2π √(KG/W)
F = 60/2x3.14 √(1.25x386/9.6) = 67.9 cpm
G = Acceleration of gravity
W = Weight of mass, lb = 9.6
Movement of weight, in. = amplitude

Fig. 2—Resonant frequency calculations for a spring-suspended weight excited.

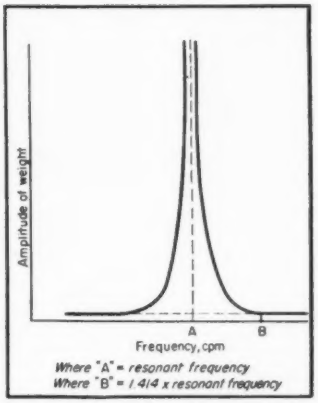


Fig. 3—Amplitude-frequency curve of the weight sprung vibrating system.

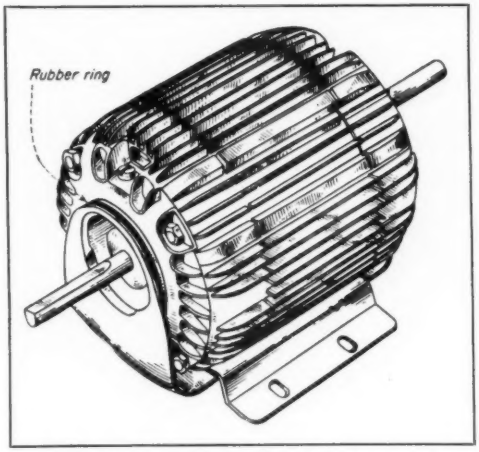


Fig. 4—A rubber ring mount at each end of this motor isolates 60 cycle vibrations that occur with alternating current.

Fig. 5—Motor mounts used on the 1949 Buick. They are located as near to the engine's CG and CR as practicable.

ing structure will be reduced to $\frac{1}{8}$ of that which would be present if the motor was bolted rigidly to the structure.

Center of Rotation

Naturally there is a right and a wrong location for a mount if the best results at the most economical cost are to be achieved. This location is the spot where movement is least and is known as the center of rotation. A mount should be placed as near the center of rotation as possible and still maintain stability. A commercial application of this is shown on Fig. 4 in which an electric motor is supported on each end by two circular rubber rings. Some types of electric motors have what is commonly called "60 cycle hum." This is the result of the 60 cps fluctuation in torque, which has been created by the reversal of the current. This torque variation produces a rotation oscillation of the motor housing about the centerline of the armature shaft. The oscillation is picked up by the supporting structure and manifests itself as an unpleasant noise. Rubber ring mounts reduce this hum to an acceptable loudness because of the transmissibility law.

Stability

It is apparent in Fig. 1 that while the spring support will effectively isolate the vibratory forces of the engine, they do not offer a stable foundation. Mounting should be placed so as to provide stability as well as to isolate vibration. So far only motion in one direction has been discussed. Actualiy any inanimate body freely suspended can vibrate in any one of six ways: longitudinally in the vertical, fore and aft, and sideways directions; rotationally about the longitudinal, vertical and cross axes. All of these directions are considered in the mounting, Fig. 5, of the 1949 Buick engine.

Damping

It was illustrated in Fig. 2 that the resonant amplitude of the weight on the steel spring was many times the amplitude of the eccentric. In fact when the steel spring was used, the stretch became so great as to become unmanageable. And if that engine were to be run at 600 rpm, it would

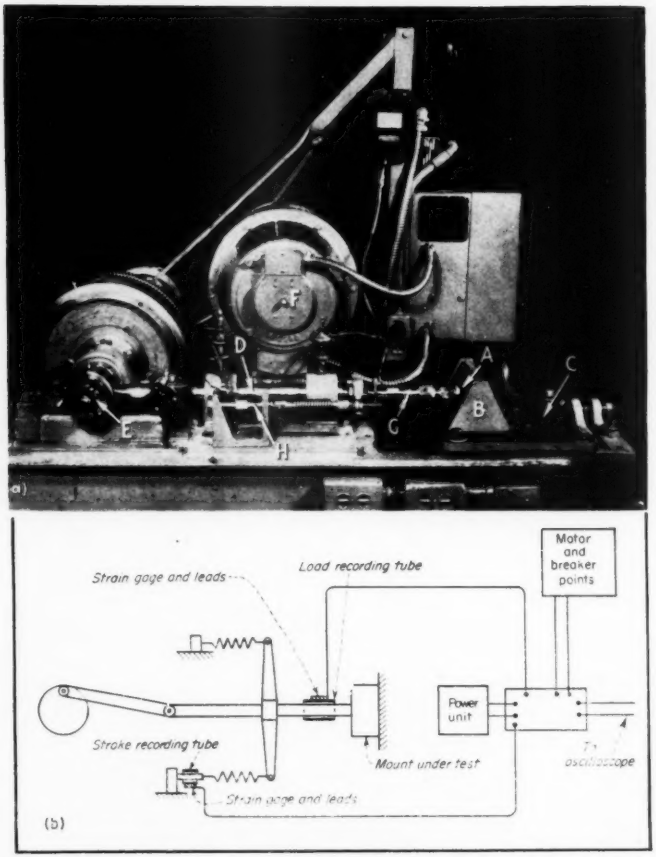


Fig. 6—Mechanical stroker for studying motor mount materials. (a) Loads applied and corresponding amplitudes are measured by wire strain gages on tubes G and H.

again be running in its resonant frequency and might destroy the steel spring mounts.

Since it is sometimes desirable to run the engine at this speed, it is necessary to control the engine's movements under this condition also. This may be accomplished as follows:

1. The resonant frequency can be further lowered to a speed which is well below the slowest speed at which the engine will run. It is assumed that the engine, upon starting, will pass through this speed before any damage is done.

2. Stops can be used to limit the travel.

3. Friction can be used in the form of dash pots, rubbing friction, or a material like GR-S rubber, which has high internal friction.

The first method alone is not always safe because of such things as prolonged cranking in cold weather. The second may create customer complaints under certain conditions because of the thumping noise created when the engine "bottoms" on the stops. A combination of the first and third methods has proven satisfactory in service and will be discussed.

GR-S rubber (Government Rubber—Styrene) is a synthetic rubber which became commercially available during the war and was found to possess excellent damping characteristics. For a comparison of its damping ability with various materials such as a steel spring, natural, neoprene, butyl rubber, see Fig. 7. GR-S rubber gave the best control and the steel spring the least, under resonant conditions.

To study materials when molded into actual mounts, the Buick Motor Division of GMC built the mechanical stroker shown in Fig. 6. Since this machine tests an actual mount, it can also be used for inspection and production control. The mount under test is located on bracket *B* which is bolted to plate *C*. This plate can be adjusted to give the desired pre-load on the mount or test sample. Movement of the mount in either shear or compression and tension loading is actuated through the reciprocating rod *D* by means of the crank at *E*. The machine is belt driven by motor *F*. Loads applied to the mount are measured by means of strain gages cemented to load recording tube *G*. The corresponding stroke is obtained from strain gages on the stroke recording tube *H*. For endurance and elevated temperature work an asbestos lined heating box is used. Endurance tests are made at 100 F temperature.

To record the hysteresis loop, Fig. 8, the signal is shown on an oscillograph which is connected to an amplifier having a power unit. Calibration to obtain correct load readings for various settings of the oscillograph controls is accomplished through breaker points operated by an electric motor. The horizontal and vertical axes of the hysteresis loop signal represent the stroke and load variation imposed on an actual mount. The area enclosed in the loop is the work lost, or the damping present in the rubber. A scale is included in the photograph as a basis for determining if any distortion or magnification has occurred during the photographic process. Three types of dynamic tests are made: (1) Constant temperature; (2) constant speed; (3) endurance. These three types of tests can be made for compression, tension, or shear loading. Fig. 9 (a), (b), (c) shows some results.

When making endurance tests it is always desirable to know, as accurately as possible, when failure occurs. With this machine it is easy to determine this point because the shape of the hysteresis loop will change as shown in Fig. 10. This mount was running under compression and tension loading and that part of the signal to the left of the Y axis remained normal, because this portion of the signal represents the compression loading. The signal leveled off to a horizontal line at the starting point of tension loading, which indicates failure. When a mount has only a small internal break in the rubber, the signal will be distorted at the same point but to a lesser degree. A comparison of the load variation just before and after failure will show a corresponding drop because of failure. If a mount breaks all the way through, only the compression load will show.

To obtain a permanent record and to assist in making calculations, life size photographs of the oscillograph image are made for each test. A 4 x 5

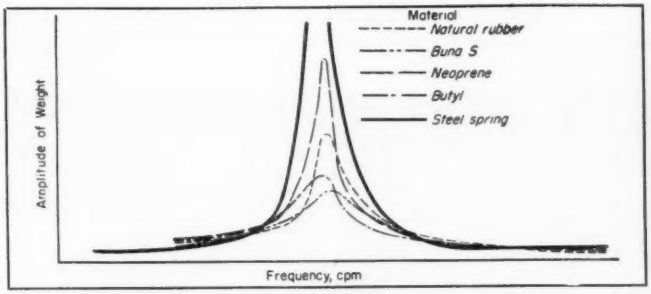


Fig. 7—Comparative damping effect of various materials. Amplitude of a weight suspended on the materials shown varies widely under resonant excitation.

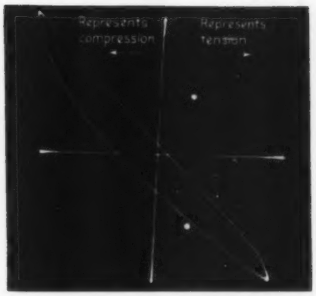


Fig. 8—Cathode ray image of a mount in action. Loop area represents work lost.

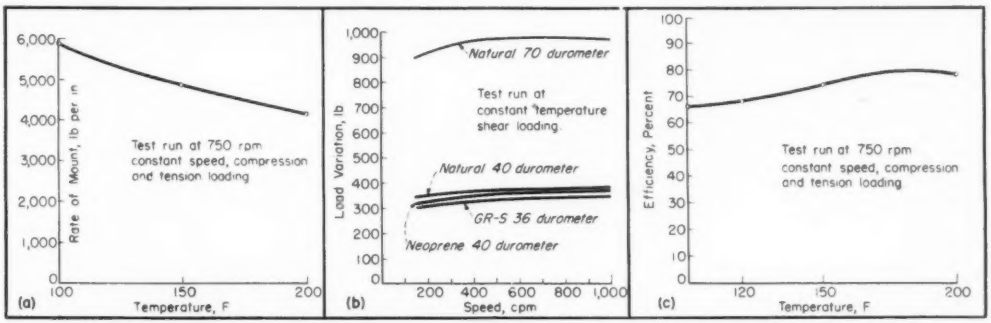


Fig. 9—Typical results from mount tests. (a) Rate-temperature chart for GR-S rubber mount. (b) Load variation-speed chart for several rubbers. (c) Efficiency-temperature chart for Butyl rubber mount. Such tests reveal important design considerations.

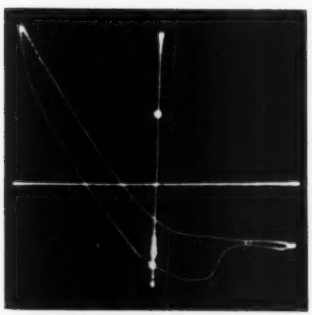


Fig. 10—How a broken mount records as a failure on cathode tube screen.

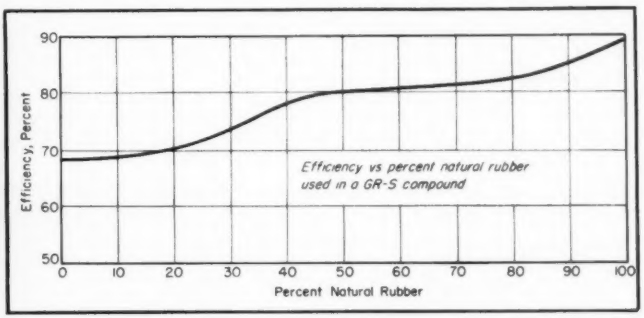


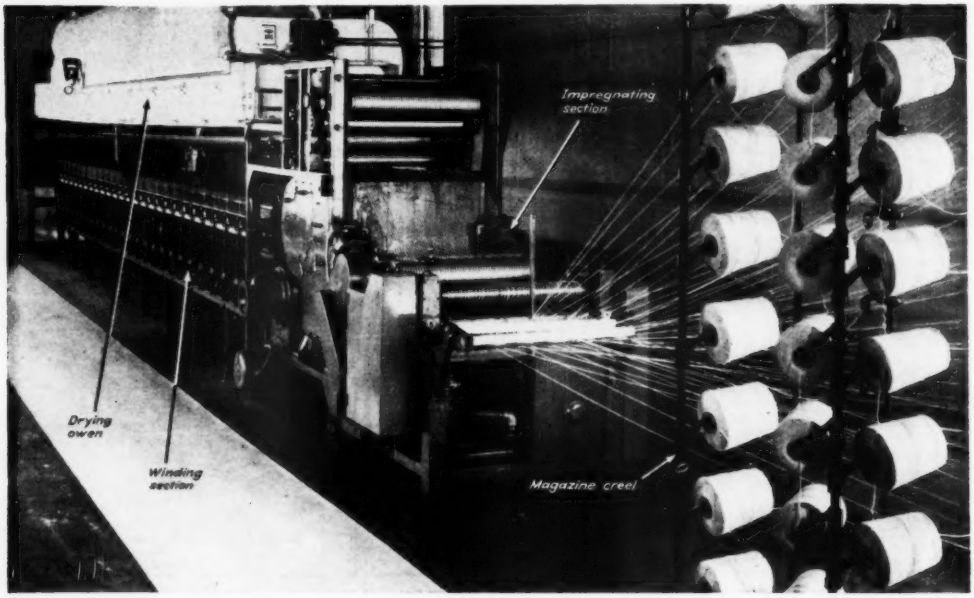
Fig. 11—Efficiency of damping, or energy absorption, varies with the percent of natural rubber incorporated in the mount material, as is shown in the above chart.

in. plate camera and fast press film is used. In the leading picture are shown typical hysteresis loops obtained with, natural, neoprene and GR-S rubber compounds.

In all fairness, it should be stated that while these natural and neoprene compounds do not show much internal friction they can be compounded to increase this quality. A study was made to determine the variation in efficiency, Fig. 11, of the material as the percent of natural rubber was increased.

It is advisable to consult the rubber industry on any problem involving the use of rubber. They may make suggestions at the start of a project that will save the user a great deal of effort and expense. For instance, while it is desirable to have hysteresis in a damper, that same damper might be exposed to oil. Therefore, a GR-S rubber which has good damping qualities but poor oil resistance, could not be used as the damping agent. It would be necessary to use a compound of either neoprene or Buna N in which the hysteresis quality has been incorporated. Then, again, it might not be desirable to use rubber at all because of heat. For such installation conditions, a mechanical damper of the dash pot or shock absorber type might be indicated.

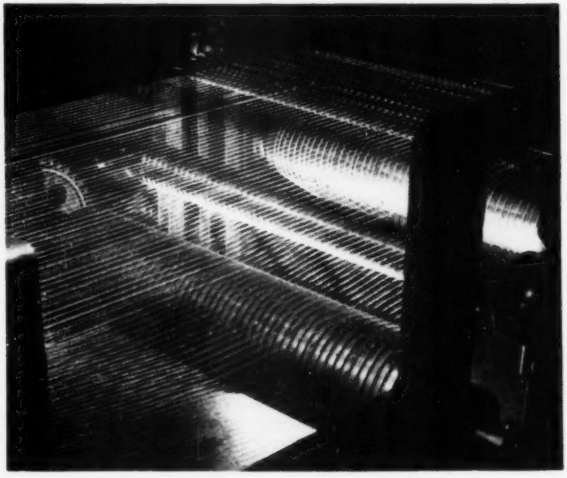
While this article has dealt primarily with linear mechanical vibration forces there are also torsional and acoustical vibrations, and these are controlled in much the same manner as linear types.



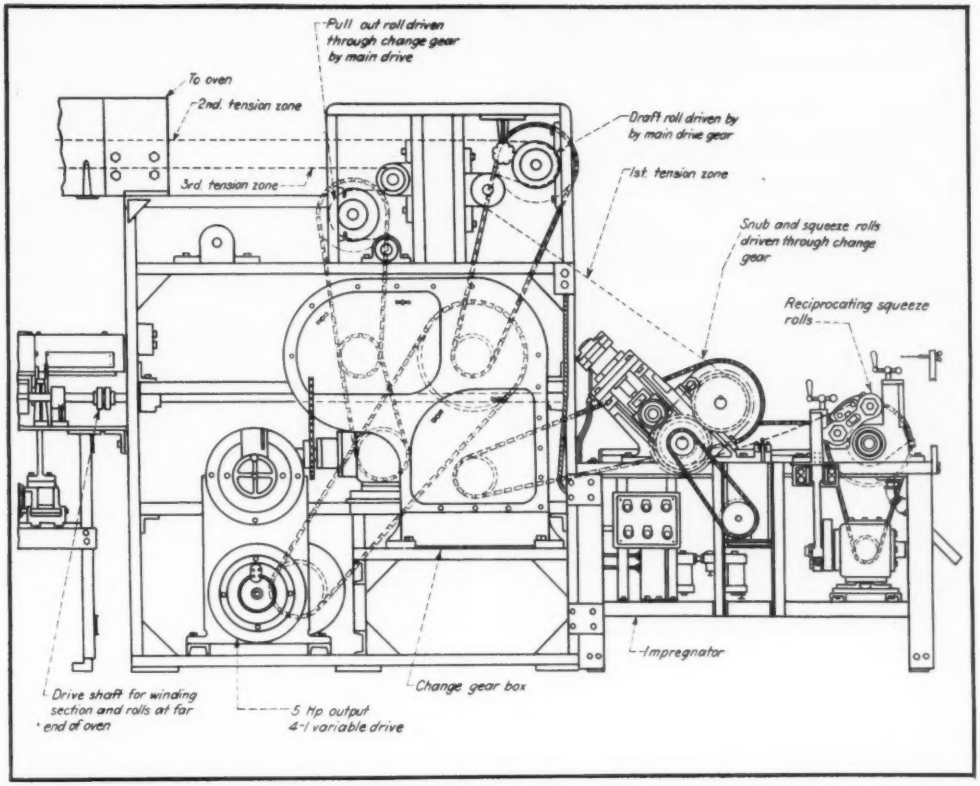
WELDED STEEL SECTIONS form framework. A standard oil burner unit provides heat for the large drying oven.

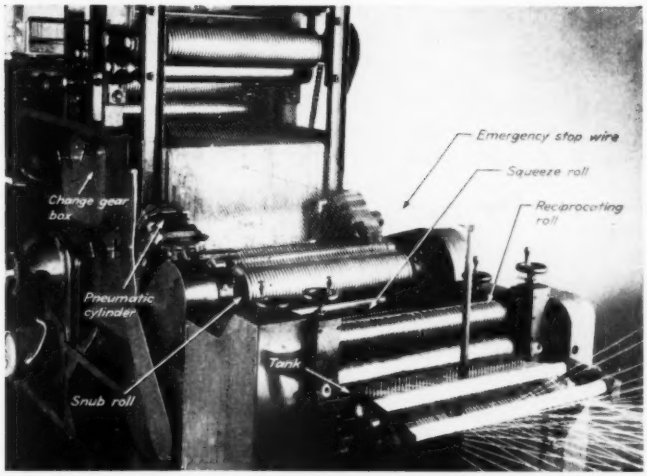
Change Gears Control Yarn Tension in Fiber Bonding Machine

By impregnating yarns with synthetic resins, the Dan River Mills "Fiber Bonded" process increases tensile strength of textile yarns. This one machine performs all stages of the process —unwinding, impregnation, stretching, curing and rewinding. Critical feature in the operation is yarn tension, which must be varied for different phases of the process and for different textiles. The machine, which is manufactured by Walter Kidde & Co., Belleville, N. J., employs change gears to obtain the required accuracy and flexibility of yarn tension.



MACHINE STOPS automatically when a strand of yarn breaks. If any one of the bent wire fingers riding on the strands is allowed to drop, it contacts a transverse rod thus closing a low voltage pilot circuit.


Pull out roll driven through change gear by main drive
To oven
2nd. tension zone
3rd. tension zone
Draft roll driven by by main drive gear
1st. tension zone
Snub and squeeze rolls driven through change gear
Reciprocating squeeze rolls
Impregnator
Change gear box
Drive shaft for winding section and rolls at far end of oven
5 hp output 4-1 variable drive



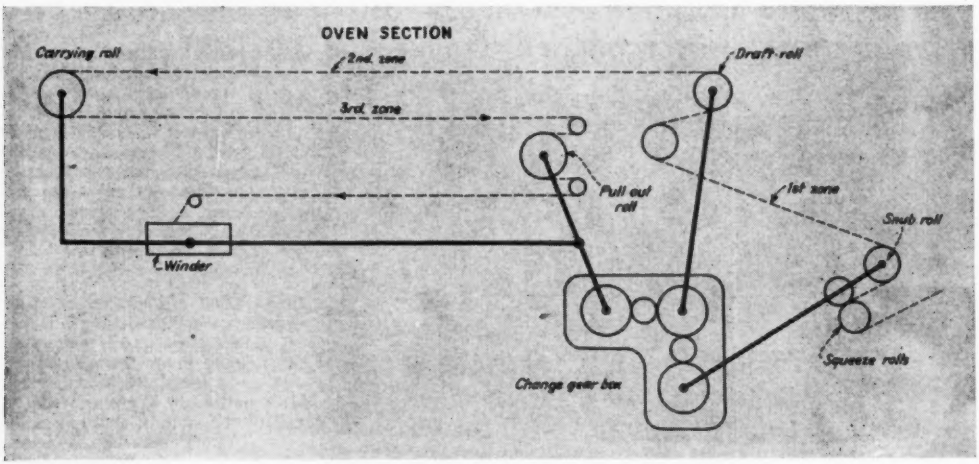
THREE DISTINCT tension zones control elongation of yarn during bonding process. Tension in each zone must be varied to suit conditions required for different types of yarn. Pull is placed on strands by driving each succeeding roll at a faster rate than its predecessor. To achieve the necessary speed synchronization, a single electric motor powers all rolls through a series of interconnected chain drives.

FIRST ROLL of impregnating section has two smaller reciprocating rolls bearing against it which twist and untwist the yarns to insure thorough dispersion of the resins. Reciprocating rolls are connected by a pivoted yoke. A pair of rubber rolls, operating under pressure from pneumatic cylinders, squeezes out surplus resins and passes yarns around snub roll into high tension zone. *(continued on next page)*

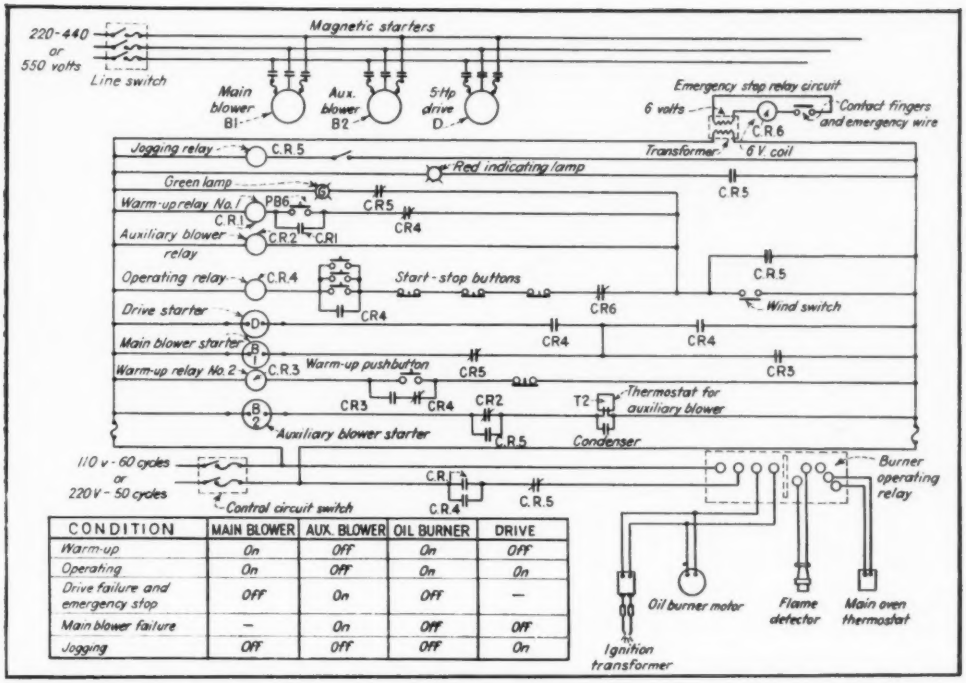
Fiber Bonding Machine (continued)

TO SIMPLIFY threading of yarn, two cables are passed through wide grooves cut into ends of each roll. A bar fastened to these cables pulls yarn strands through machine when drums are rotated. Take-off from winder drive shaft powers cable drums. After threading, rotation of drums is stopped by disengaging clutch.

CHANGE GEARS determine speed of rolls and hence zone tension. For easy calculation, change gears are cut so that one tooth is equivalent to one percent yarn elongation. Idler gears are mounted on slotted sectors to allow for various change gear diameters. Rotation of gears is such that idlers will be pushed away if sector lock nuts are not tightened.

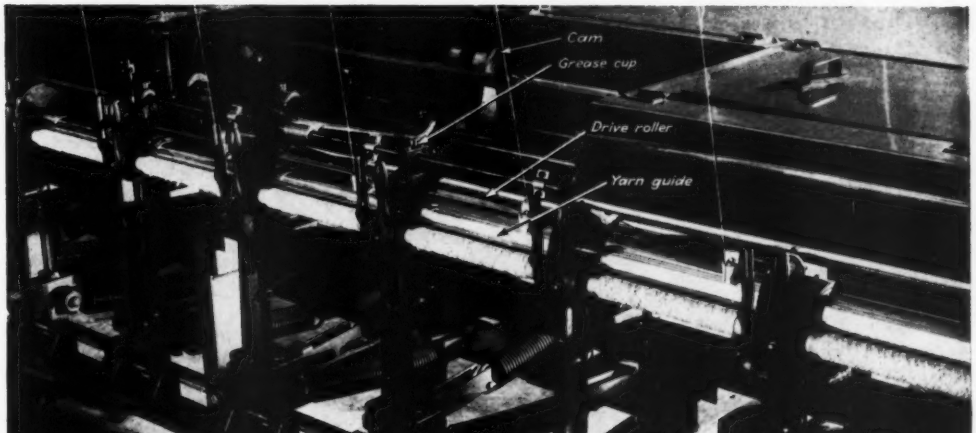


SCHEMATIC DRAWING of yarn path through machine indicates operations controlled by each change gear. Third gear also actuates long shaft running back through machine to winder and carrying roll.



CONDITION	MAIN BLOWER	AUX. BLOWER	OIL BURNER	DRIVE
Warm-up	On	Off	On	Off
Operating	On	Off	On	On
Drive failure and emergency stop	Off	On	Off	—
Main blower failure	—	On	Off	Off
Jogging	Off	Off	Off	On

ALL PHASES of operation are interconnected and controlled electrically as shown in this wiring diagram. Wind switch in the operating relay circuit prevents the starting of the machine without passing through the required warm-up stage. When an emergency condition occurs, a six volt pilot relay opens the normally closed contacts in the line of the operating relay. This cuts out the drive, main blower and oil burner. As soon as the main blower stops, the wind switch opens, deenergizing the normally closed auxiliary blower relay. The auxiliary blower will then operate until the oven has cooled sufficiently to prevent burning of the stationary yarn.

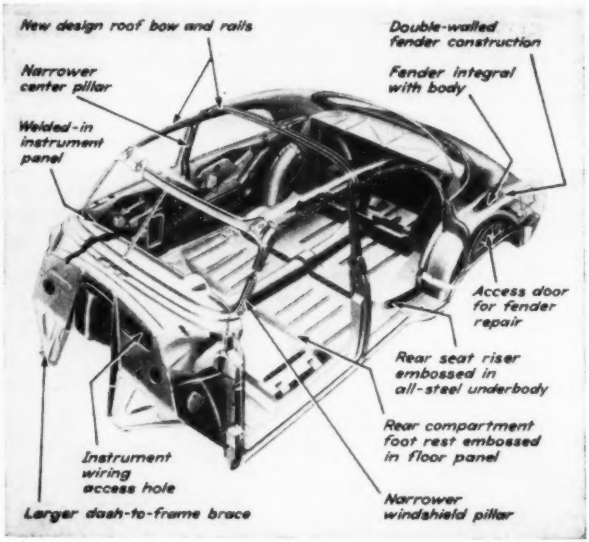


SPRING-LOADED LEVERS hold winding spindles against revolving drums. Yarn guides reciprocate rapidly along axis of spindles to arrange strands into an evenly wound package. Two cylindrical cams actuate the guides.

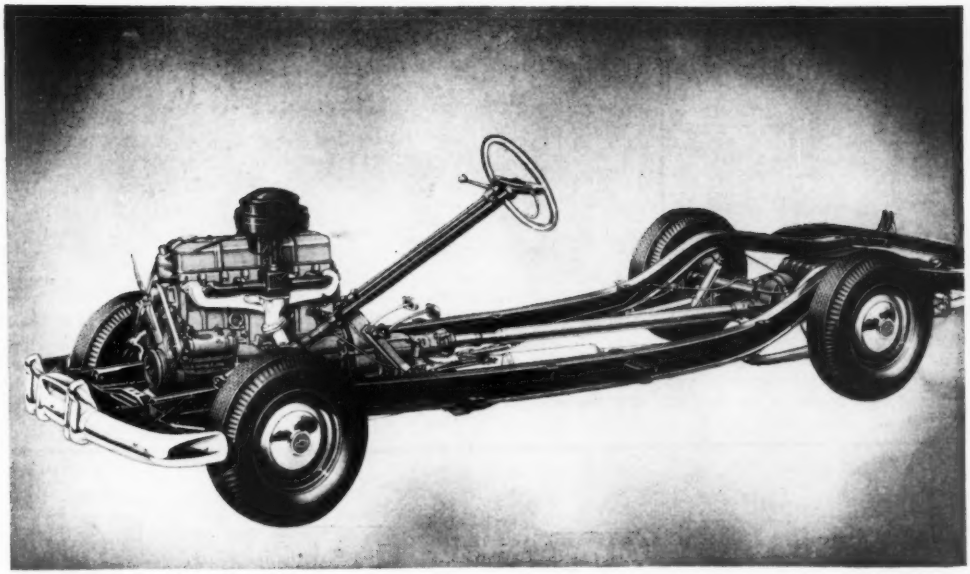
REAR FENDERS project slightly to provide some protection for the sides of the car in side-swipe accidents. The front grille is assembled from chrome plated steel stampings. This construction effects a considerable weight reduction over the die cast grille formerly used. Door handles are fixed and contain a thumb button to operate latch.

Chevrolet Changes Front Suspension

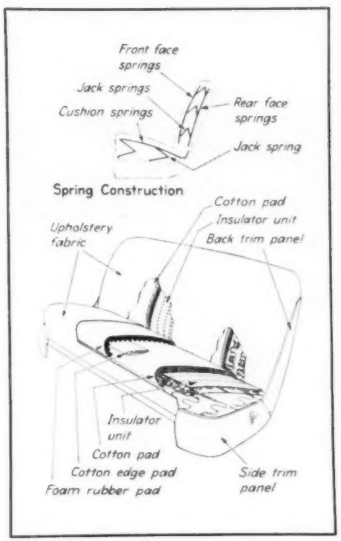
The Chevrolet for 1949 features a smaller version of the Fisher "Futuramic" body previously introduced on other General Motors cars. Glass area has been increased, seats widened and the passenger compartment moved forward of the rear wheels. The front suspension includes many changes intended to reduce weight and simplify assembly and service. A number of forged parts have been replaced by stampings. Other modifications include centerpoint steering system, airplane-type shock absorbers and manual shifting, which replaces the vacuum assisted type used for many years.


New design roof bow and rails
Double-walled fender construction
Narrower center pillar
Fender integral with body
Welded-in instrument panel
Access door for fender repair
Rear seat riser embossed in all-steel underbody
Rear compartment foot rest embossed in floor panel
Instrument wiring access hole
Larger dash-to-frame brace
Narrower windshield pillar

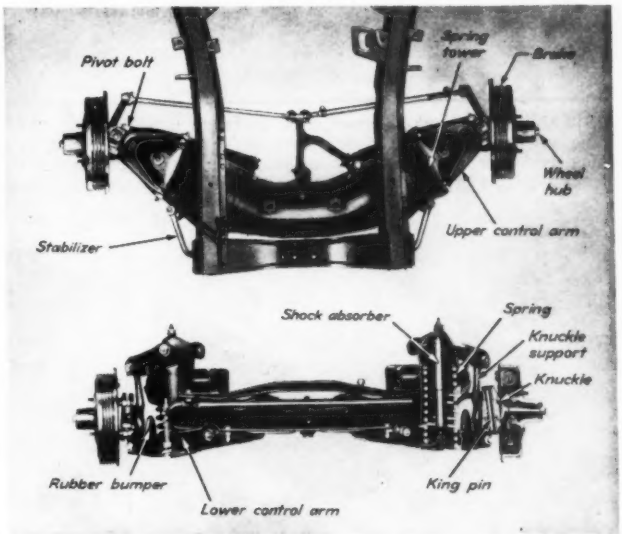
THE INCREASE in glass area was achieved without sacrifice in structural strength by taking full advantage of the available steel sections. The instrument panel, now welded into the front end of the body, serves as a lateral brace. A steel bow, corrugated for stiffness, is welded between center pillars to improve rigidity of roof rails. Bow completes a mid-section frame formed by the pillars and underbody cross member.



ENGINE has been moved forward to accommodate the relocated passenger compartment. Heavier coil springs are used to support the increased front end load. These springs have a deflection rating of 340 lb per in. compared to 300 lb per in. on the 1948 cars. A one in. reduction in wheelbase and a slightly narrower frame save weight and material.

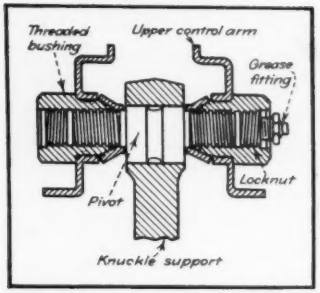


ALTHOUGH THE CAR is lower and shorter than the 1948 model, thinner seat cushions help to maintain ample leg and head room. Flat steel springs now used in seats and seat backs take less space than the coil springs they have replaced.

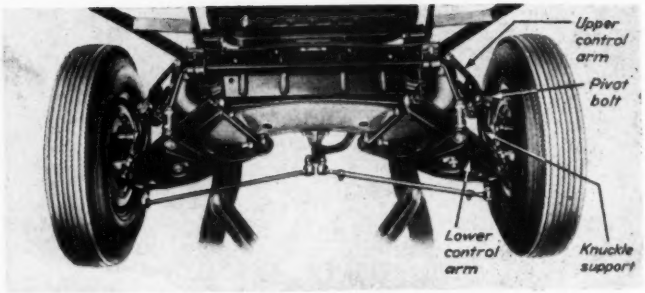


FRONT SUSPENSION embodies many changes to reduce weight and simplify assembly. Differences between many right and left hand parts have been eliminated. Airplane-type shock absorbers are used for the first time by Chevrolet. These are mounted coaxially within the coil springs and are fastened to the spring towers by bolts cushioned by rubber grommets. Symmetry of steering system is visible in this view. *(continued on next page)*

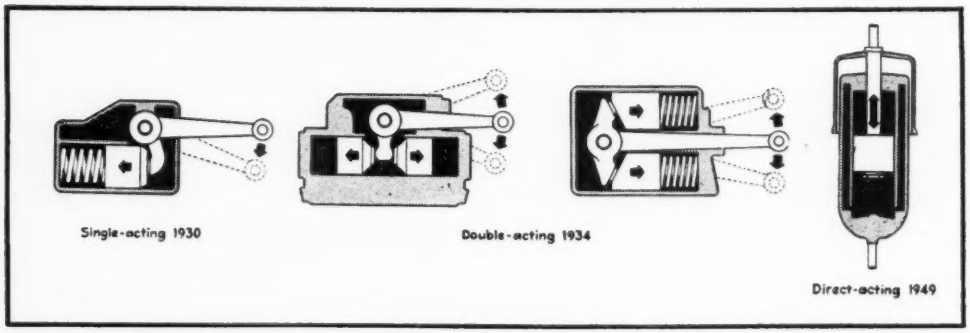
Chevrolet (continued)



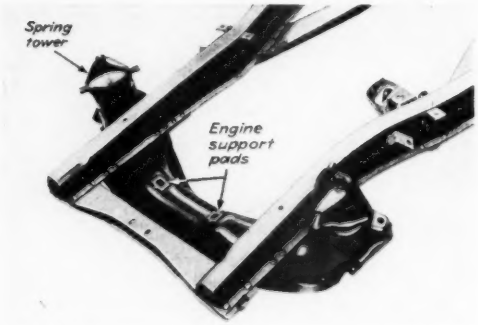
SELF-LOCKING threaded bushings attach pivot bolts to upper control arms. Pivot bolts control the inclination of the knuckle support in two planes at right angles to one another.



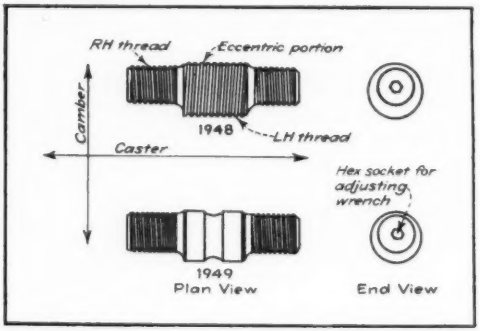
UPPER AND LOWER CONTROL ARMS are stampings now, instead of forgings. These assemblies are lighter by 29 and 21 percent, respectively. To develop stamped parts capable of equalling the performance of forgings, extensive use was made of the brittle coating technique of experimental stress analysis. Each part was redesigned many times until satisfactory test results were obtained.



AIRPLANE-TYPE shock absorbers mark the fourth step in the evolution of Chevrolet shock absorber design. Direct acting shocks are lighter in weight and simpler to install than cam and lever types. The longer piston stroke displaces a greater volume of oil which materially improves the damping effect. Bodies of the direct acting shock absorbers are permanently sealed and thus will not require refilling as cam and lever types usually do.



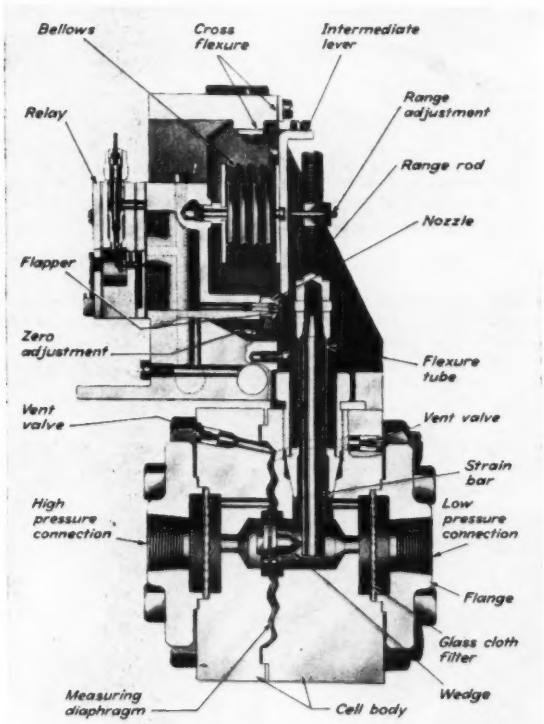
FRONT SUSPENSION cross member supports the front of the engine and also serves as a housing for the coil spring assemblies. This member consists of a semi-tubular upper section which changes sharply to a nearly flat plate at the bottom. Design combines the torsional rigidity of a tubular member with the beam stiffness of a box section.



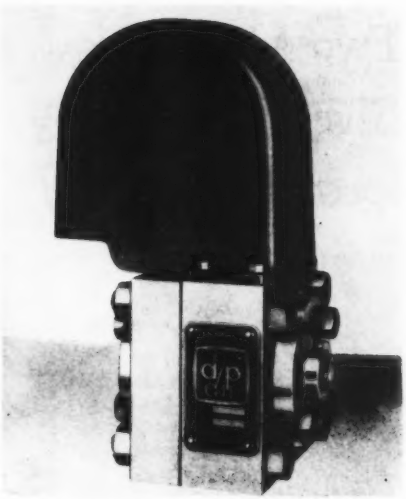
NEW PIVOT BOLT simplifies caster and camber adjustment. Previously, turning the pivot bolt for a camber adjustment had a compound effect on caster. Not only did the pivot bolt advance in the upper control arm but the knuckle support moved forward in respect to the bolt. Any attempt to adjust camber rapidly changed caster.

Air-Actuated Device Measures Differential Pressures

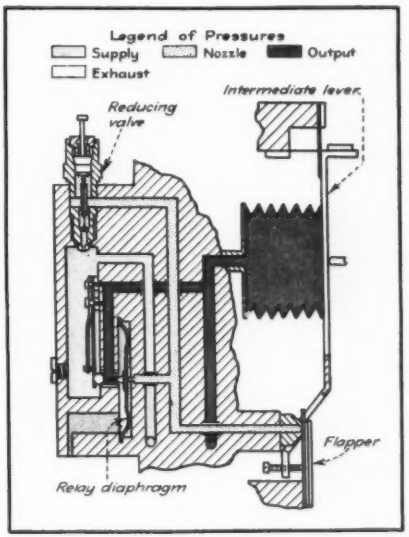
The D/P Cell was developed by the Foxboro Co., Foxboro, Mass., to replace mercury-filled and spring-operated manometers. It converts differential pressure into proportional air pressure which can be used to drive remotely located indicators, recorders or controlling mechanisms. The cell requires a 17 psi air supply which is exhausted at a rate of 0.5 cfm. A feature of the device is that there is no appreciable movement of the working parts.



PRESSURES are applied to opposite sides of the diaphragm through the high and low pressure connections. The resulting differential pressure, multiplied by the effective area of the diaphragm, produces a force which is transmitted through the force bar to the range rod. This force is then transmitted to the flexure-pivoted intermediate lever which bears against the flapper. A flexible stainless steel tube serves as a line fluid seal as well as a fulcrum for the force bar and range rod.



STAINLESS STEEL construction of cell is resistant to most corrosive fluids. The devise is suitable for measuring differential pressures of gases as well as liquids.



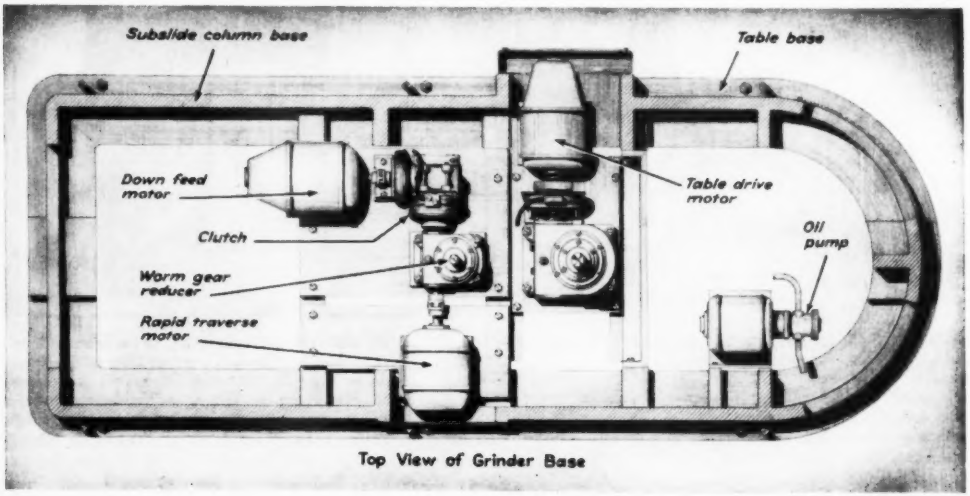
ANY SLIGHT MOVEMENT of the intermediate lever forces the flapper against the nozzle and raises pressure in the nozzle line. This causes the relay diaphragm to bulge and widens the ball valve opening. Bellows pressure increases until it balances force imposed by range rod, thus, bellows pressure is always exactly proportional to differential pressure on the diaphragm.

Two Motors Give Wide Speed Range to Grinder Head

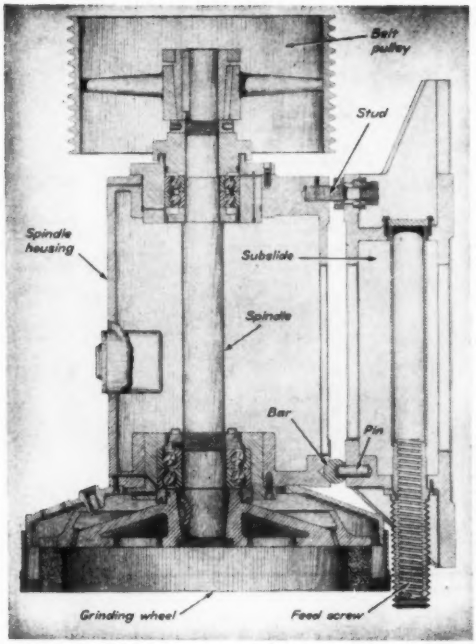
The movement of the head of this vertical spindle surface grinder is adjustable between wide speed limits without the necessity of gear or belt shifting. Two motors of entirely different characteristics drive the feed screw that raises and lowers the grinding head. Each motor operates independently and covers a definite range of speeds. Although the grinder is powered principally by alternating current, a d-c motor was selected to lower the head during grinding because of the simplicity of speed regulation of direct current motors. An a-c motor moves the head during elevation or when fast lowering is called for. The grinder is manufactured by Charles H. Besly & Co., Chicago.

AN ELECTRIC MOTOR, installed in base of machine, rotates the table so that any sector of the work surface may be brought under the grinding wheel. Table diameter is 90 inches.

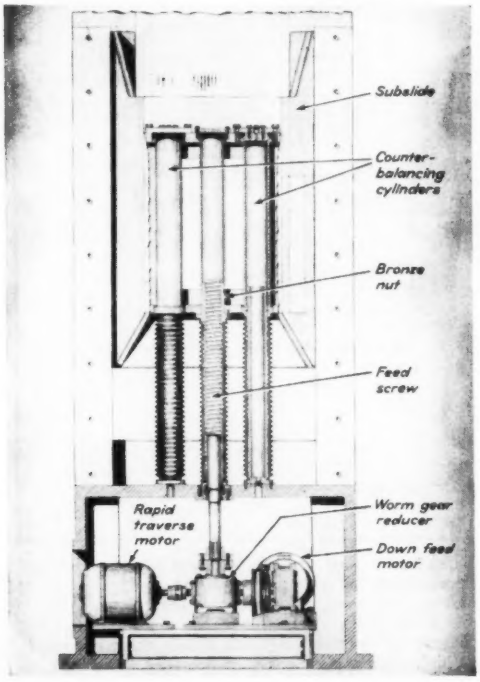
TWO SEPARATE MOTORS connect to input shaft of worm gear reducer which actuates feed screw. Under automatic down feed conditions, a one hp d-c motor controls movement of the head. This motor operates through its own high ratio gear reducer and has variable resistance in series with it for speed adjustment. For rapid elevation of the grinding head, the clutch of the feed motor is disengaged and the three hp, a-c motor set into operation.

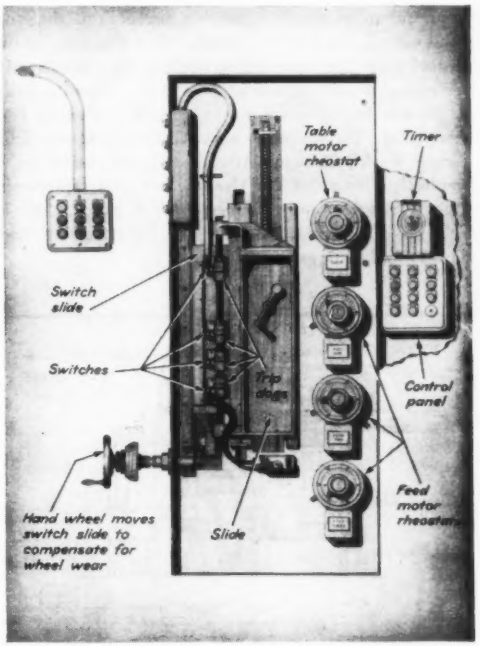


Top View of Grinder Base



TO INSURE that grinding wheel is accurately aligned in relation to plane of table, position of spindle housing is adjustable. The adjustment is made by means of the stud which fastens the housing to the subslide. Loosening stud locknuts permits movement of housing toward or away from subslide. In addition, spindle housing can be shifted across face of subslide by turning eccentric stud bushing. A groove in the bottom of the housing rests against a bar which is pinned at its midpoint to the subslide. This construction makes housing free to pivot about its lower edge in both planes of adjustment.



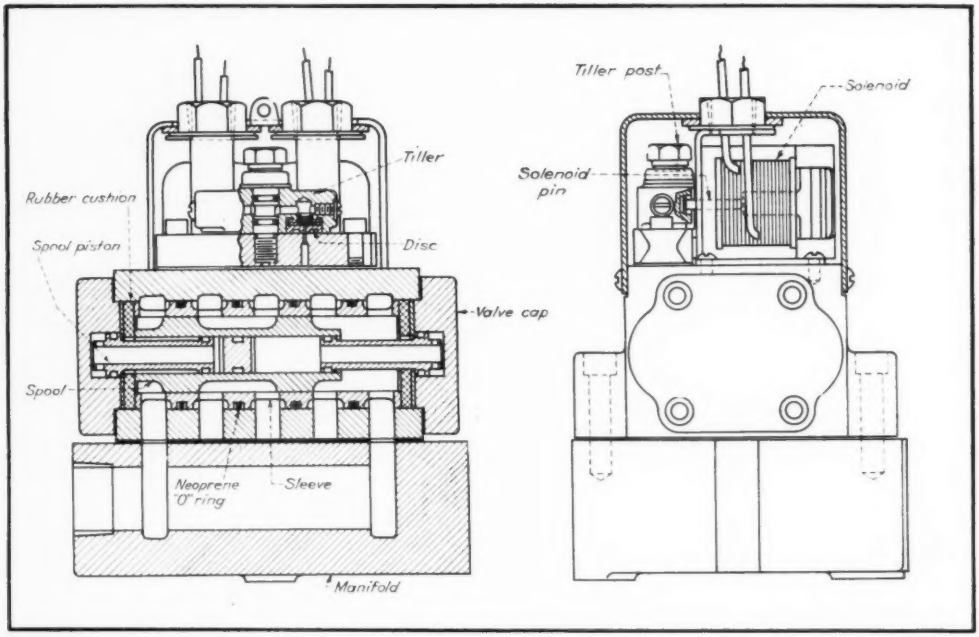


RATE OF DOWN FEED is automatically reduced at three stages of the grinding process. This is accomplished by means of a slide which moves as a unit with the grinding head. As head descends, dogs carried by slide close switches which add resistance to circuit of feed motor thus slowing its speed Bottom switch stops feed motor and starts timing unit. At end of established time interval, timer relay starts rapid traverse motor which raises head from work.

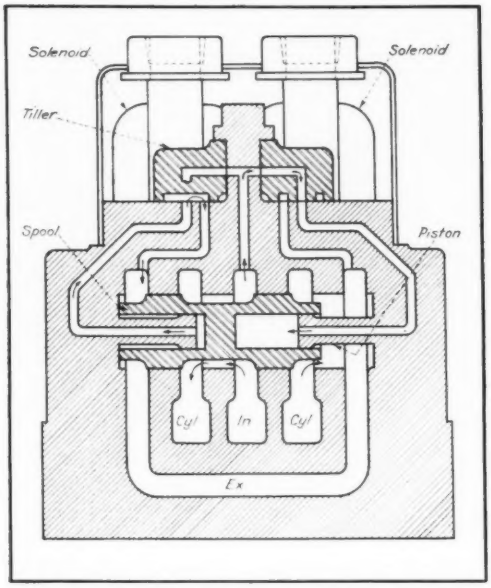
SUBSLIDE which supports grinding head and 100 hp drive motor operates in ways of heavy steel column at rear of machine. Weight of subslide assembly is in excess of that required to hold head against the work and must therefore be counterbalanced by two hydraulic cylinders. Rubber boots protect pistons and the three in. diameter feed screw which actuates subslide. Splined coupling at lower end of feed screw prevents any portion of thrust load from being transmitted to gear reducer.

Solenoid Valve Draws No Holding Current

Air pressure in place of magnetizing current holds the spool of this valve in the desired position. The valve contains two solenoid coils. The solenoids do not shift the spool directly; they control a small volume of air which actuates the spool. Air pressure locks the spool even after the coils have been deenergized. The valves are manufactured by Hanna Engineering Works, Chicago. After installation, valve can be completely dismantled for cleaning or parts replacement without disturbing pipe connections. A gasket, 0.01 in. thick, serves as a seal between ground surfaces of body and manifold castings.



SPOOL RECIPROCATES along its horizontal axis in a cast nickel-iron sleeve. Neoprene rings act both as cushioning spacers between sleeve and body and as seals between air passages. Warping or distortion of valve body is taken up by expansion or contraction of neoprene and does not affect honed bore of the sleeve. The spool is also cast of nickel-iron, then ground, chromium-plated and honed for an airtight fit with the sleeve. Sharp edges of spool lands provide a wiping action to remove foreign matter from sleeve walls. At both ends of its stroke, spool hits synthetic rubber cushions which absorb noise and shock. For high-speed applications quiet operation is essential.

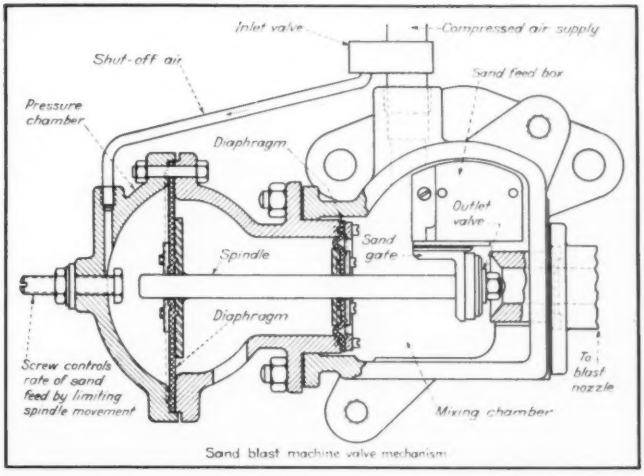


OSCILLATING TILLER governs operation of the valve. When solenoid on right is momentarily energized, tiller takes position shown in this schematic drawing. Inlet air passes up through axis of tiller, then down into right hand chamber of spool. Pressure forces spool to left and holds it there. Air in left hand chamber of spool is discharged to exhaust through annular groove in tiller disc.

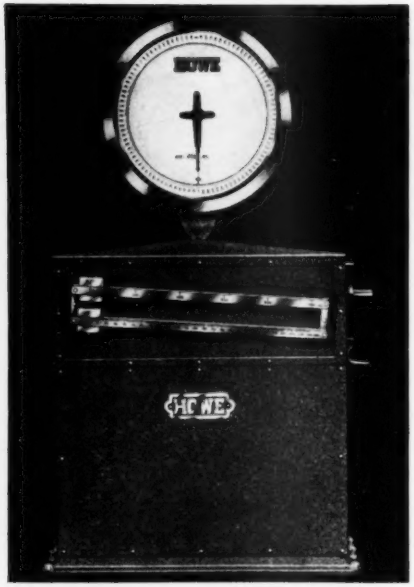
PILOT VALVE TILLER may operate at speeds of 1,000 cpm and is therefore cast from magnesium alloy to reduce inertia. Spring loaded bronze discs, inserted in each end of tiller, seat against air ports in pilot valve base. Inlet air that motivates spool passes through small hole in center of disc. Trepanned annular groove admits air from collapsing section of sleeve cylinder to exhaust.

Diaphragms Actuate Sandblast Valve

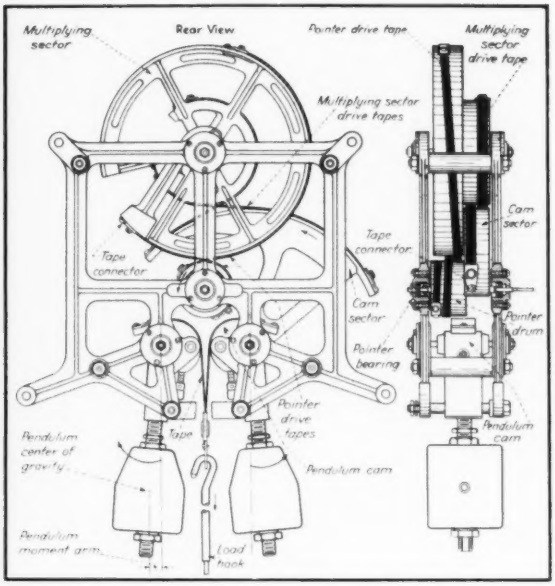
A SINGLE VALVE controls air supply, abrasive feed and blast in the sandblasting machine developed by the O. Granowski Co., Melbourne, Australia. Since the three functions are regulated simultaneously, there is no waste of sand or air after blast shut-off as occurs when separate valves are employed. When the inlet valve is turned to the "on" position, compressed air is admitted to the mixing chamber of the valve mechanism. Pressure causes the diaphragm to bulge, moving spindle to the left and opening sand gate and outlet valve. When blasting operation is completed, the inlet valve is turned to divert air supply from mixing chamber into sealed pressure chamber. Then, the large diaphragm pushes spindle to right, closing sand gate and blast outlet.



Sand blast machine valve mechanism



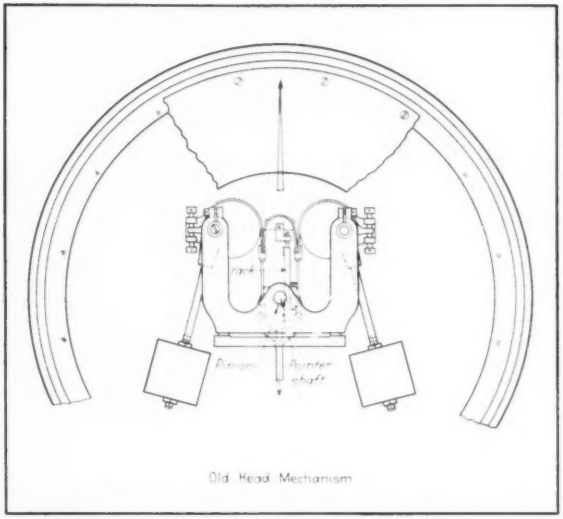
SCALE MECHANISM and lever system are completely assembled within a cast iron cabinet. The chrome plated poises slide on stainless steel beams. Moving upper poise to right increase scale capacity as much as chart capacity. Tare up to 250 lb is compensated for by adjusting the lower poise.



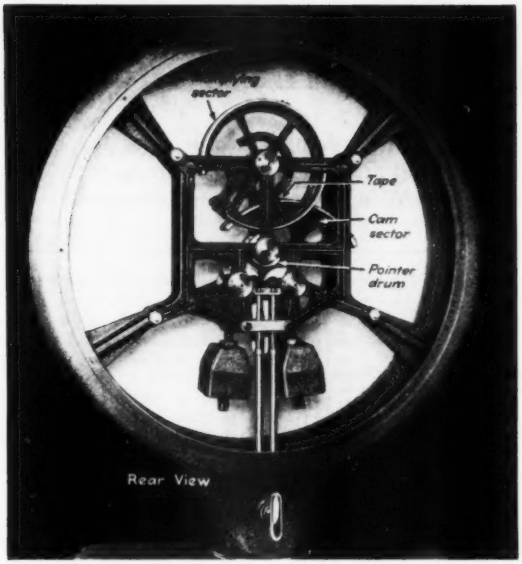
STEEL TAPES translate downward pull of hook into rotation of dial pointer. When a force is applied at the hook, the pendulums move upward until their countermoment has increased sufficiently to balance the hook force. Maximum load handled by head mechanism is 20 lb, which is sufficient to pull pendulums through 36 deg arcs and rotate pointer 360 degrees.

Steel Tapes Drive Scale Pointer

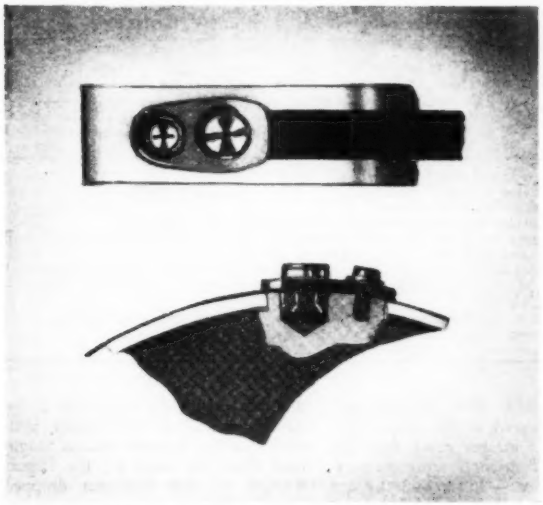
Steel tapes have replaced the rack and pinion mechanism formerly used to actuate the pointer of this industrial scale. The tape drive has increased weighing accuracy by eliminating two of the principal sources of error—gear teeth friction and wear. Tapes are fabricated from a high cobalt alloy. The scale, manufactured by the Howe Scale Co., Rutland, Vermont, also employs a semi-automatic method of adding weights to a counterpoise bucket for increasing weighing capacity. The scale is supplied in a cabinet ready for on-site connection to weighing platform. Platforms are specially constructed to suit application.



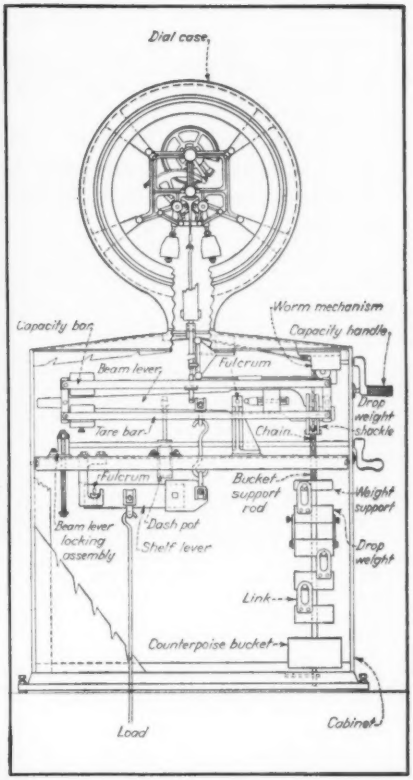
IN PREVIOUS VERSIONS of the scale, the applied load actuated a rack and pinion against counterforce of pendulums. The mechanism was simple but subject to inaccuracies because of friction and gear tooth wear.



WHEN RACK and pinion were eliminated, a new mechanism was required to amplify the 36 deg pendulum arc into full scale pointer deflection. Tape-driven drum sectors were developed for this purpose. The cam sector, which is integral with the right hand pendulum, moves counterclockwise when pendulum is raised. Tape connected between left extremity of cam sector and small drum of multiplying sector rotates multiplying sector which in turn actuates the drum of the dial pointer.



PIN CONNECTORS secure tapes to the pendulum cams and rotating sectors. Although tape is fixed tangentially, it can move slightly about the axis of the pin to align itself and thus avoid twisting stresses.



LEVER SYSTEM reduces platform load to a small force which is measured by pendulum mechanism. The beam lever supports tare and capacity bars as well as counterpoise bucket. When an object is placed on the platform, the equilibrium of the beam lever is upset and the resultant force is transmitted to head mechanism. Sliding poises to right or adding weights to the bucket counteracts the load moment and increases scale capacity. The capacity handle controls position of the link-connected weights. Each turn of handle places one weight on bucket and increases scale capacity by one full dial reading.

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R. H. HENKE
Allegheny Ludlum Steel Corporation

WHILE THERE IS LITTLE CHANGE in the physical properties of ferritic or pearlitic stainless steels (straight carbon-chromium types) as temperature is decreased to zero F, the impact strength often decreases 90 percent or more below the values obtained at room temperature. Consequently, austenitic stainless steels (chromium-nickel types) are preferred for industrial equipment that must have high resistance to impact when subjected to sub-atmospheric temperatures in service, because these materials retain most of their toughness even at extremely low temperatures. If the equipment is to operate under pressure, the metal of which it is made must have a minimum impact resistance of 15 ft-lb Charpy keyhole notch or 18 ft-lb Izod vee notch at the temperature of service, according to the ASME code on unfired pressure vessels, and so the use of austenitic stainless steels, rather than the ferritic or pearlitic grades, often is mandatory.

Toughness may be defined as the resistance of a material to shock loading, and can be determined by either the Charpy or Izod tests. While the data obtained by these tests cannot be used by the design engineer in the same manner as tensile strength data, it is sufficient to indicate whether the loss in ductility under a given service condition may cause failure under quickly applied loads. The ferritic and pearlitic stainless steels have a transition temperature range between the tough condition and the completely brittle condition which is influenced by cold working and heat treating, velocity at which the load is applied, and severity of the notch. A rapid blow in the presence of a sharp notch, as in the above mentioned impact tests, may reveal brittleness in an unalloyed steel at a temperature slightly below room temperature. Reduction in the severity of the notch and reduction in velocity of the blow will each progressively lower the apparent embrittling temperature. Slow loading, such as is encountered in the tensile test, (0.05 to 0.5 in. per min) may fail to indicate brittleness until temperatures as low as −250 to −300 F are encountered.

An example of the variations that are obtained from different specimens by different investigators is the data available on 12 percent chromium stainless steel. Data from tests at the Allegheny-Ludlum laboratories indicates that this material retains toughness down to −80 F; the impact strength of one specimen dropped from 42 ft-lb at room temperature to 22 ft-lb at −80 F (Charpy keyhole notch), while the impact strength of another dropped from 58 ft-lb to 34 ft-lb over the same temperature range.

Table I—Impact Resistance of Annealed Austenitic Stainless Steel

AISI Type No.	Composition				Impact Resistance, Ft-lb				
	C	Cr	Ni	Others	Room Temp	−25 F	−80 F	−320 F	Reference
301	0.11	17.97	7.80		110	110		110	
	0.10	17.35	7.63		114	115	114		b
302	0.10	17.95	9.44		110	110		108	
	0.14	17.90	9.00		95*			88*	d
	0.11	18.30	11.1		114		118	100	f
	0.09	17.54	9.24		80*	78*	81*		e
	0.088	18.51	9.65		119	117	113	119	a
304	0.06	18.43	8.81		110	110		110	
	0.06	17.87	9.79		84*			76*	c
	0.05	18.7	9.00		110			90*	d
				Ti					
321	0.06	18.21	9.60	0.60	110	110		110	
	0.086	17.74	10.71	0.67	110*	83*	79*		
	0.09	17.1	8.80	0.47	105*			89*	d
				Cb					
347	0.07	18.18	11.02	0.98	110	110		86	
	0.07	18.62	10.98	0.92	110	110	110		
		Not Known			73*	64*	58*		
					95			104	a
				Mo					
317	0.07	18.42	13.95	3.06	110	110	110	110	
					110*	110*	110*		

* Charpy Keyhole Specimen; all other tests Charpy "V" Notch Specimen.

a— Electro – Metallurgical Corporation.
b— Rustless Iron & Steel Corporation.
c— International Nickel Company
d— *Archiv fur das Eisenhuttenwesen*, Jan. 1940, A. Kirsch and G. Haupt.
e— "Endurance and Other Properties at Low Temperatures of Some Alloys for Aircraft Use," Russell & Welcker, *NACA Note No.* 381, 1931.
f— "The Mechanical Properties of Some Austenitic Stainless Steels at Low Temperatures," Colleck, MacGillioray, and Manning; *Transactions of the Institute of Chemical Engineering*, Vol. 11, 1933.

Note: All data not identified was obtained in the Allegheny-Ludlum laboratories under conditions previously described.

Other data presented by R. Sergeson in the *Transactions of the American Society of Steel Treating* places the transition temperature of 12 percent chromium steels at zero F, as shown in Fig. 1. Slight variations in compositions or other of the previously mentioned factors probably are the cause for these differences.

Annealed Austenitic Stainless Steels

Even if it is assumed that the carbon-chromium stainless steels retain toughness to the lower temperature, the austenitic steels are still much better in comparison. DeHaas and Hadfield in their paper "The Effect of the Temperature of Liquid Hydrogen on the Tensile Properties of 41 Metals" in the *Philosophical Transactions of the Royal Society of London* report that some of these steels retain a large portion of their room temperature toughness at temperatures as low as —423 F, which is just 37 F above absolute zero.

A compendium of test results and a partial resume of data from the literature on the impact properties of the various austenitic stainless steels of the 18-8 variety is given in Table I. Unless otherwise stated, these tests were run using a Charpy vee notched specimen instead of a keyhole specimen. Testing was done on a Reihle impact testing machine having a pendulum velocity of 12.75 fps. Depending upon the temperature desired, combinations of dry ice with gasoline or alcohol were used for temperatures down to —80 F, and liquid nitrogen was used for —320 F. All specimens were held for ½ hr at temperature prior to testing.

As shown, the wrought annealed austenitic stainless steels retain most of their room temperature impact toughness at temperatures as low as —320 F. Variations have been found in different lots of AISI Type 347, but the impact toughness of this analysis is seldom diminished to values less than 80 ft pounds.

Dr. V. N. Krivobok of the International Nickel Co. conducted tests to determine whether long time exposure at —320 F has a tendency to age or embrittle Type 304 stainless steel. It was found there is little difference in samples exposed 30 min compared to samples exposed one year at —320 F, whether tested at room temperature or —320 F, and therefore the impact strength of these materials in service should correlate closely with the values obtained by laboratory tests.

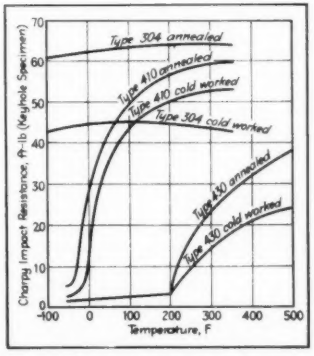

Fig. 1—Comparative impact resistance at sub-atmospheric temperatures of AISI Types 304 (austenitic), 410 (pearlitic), and 430 (ferritic) stainless steels.

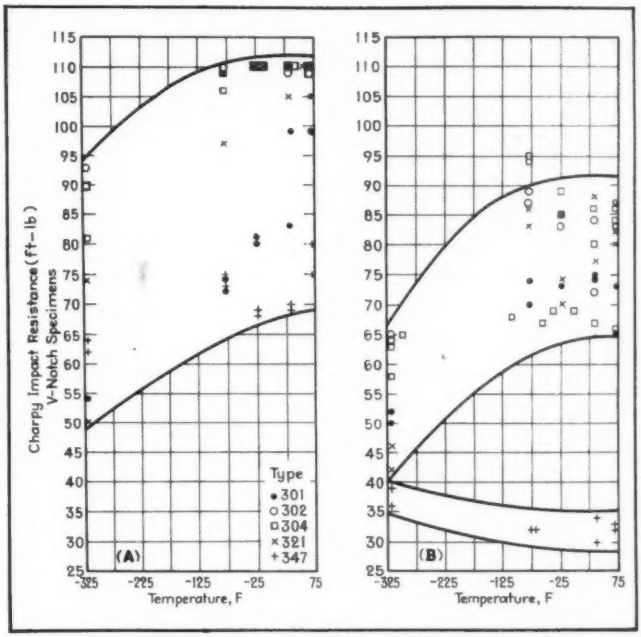

Fig. 2—Impact resistance of cold drawn austenitic stainless steels: *A*, ¼ hard; and *B*, ½ hard. Results are shown within scatter bands because of the wide variations in values obtained on similar type steels having slightly different compositions.

Cold Drawn Austenitic Stainless Steels

The fabrication of vessels and equipment used in low temperature service often involves fabricating operations such as roll forming, press brake bending, and other forming operations, all of which cold work the metal to some extent. Such mechanical hardening places the material in a state of stress, which lowers the amount of energy that can be absorbed upon impact. Cold working does not cause the austenitic stainless steels to become sensitive to decreasing temperature. It does, however, cause a general decrease in room temperature impact resistance, the magnitude of decrease varying in proportion with the amount of cold work; the toughness of cold worked samples is affected by temperature in the same manner as annealed specimens, decreasing gradually with decreasing temperature.

Impact strengths at low temperature, of AISI Types 301, 302, 304, 321, and 347 cold drawn to approximately ¼ hard (120,000-125,000 psi tensile strength) and approximately ½ hard (140,000-145,000 psi tensile strength) are shown graphically in Fig. 2. Since five analyses of steel were investigated, and impact resistance seems to vary with composition, each analysis is listed separately and the range of impact resistance is shown by a scatter band. In each instance, Type 347 exhibits greater sensitivity to cold work than the other analysis, decreasing at room temperature to 77 and 32 ft-lb impact resistance respectively. While this is the lowest value reached by the austenitic stainless steels, it does not indicate a brittle condition since many annealed carbon steels exhibit lower

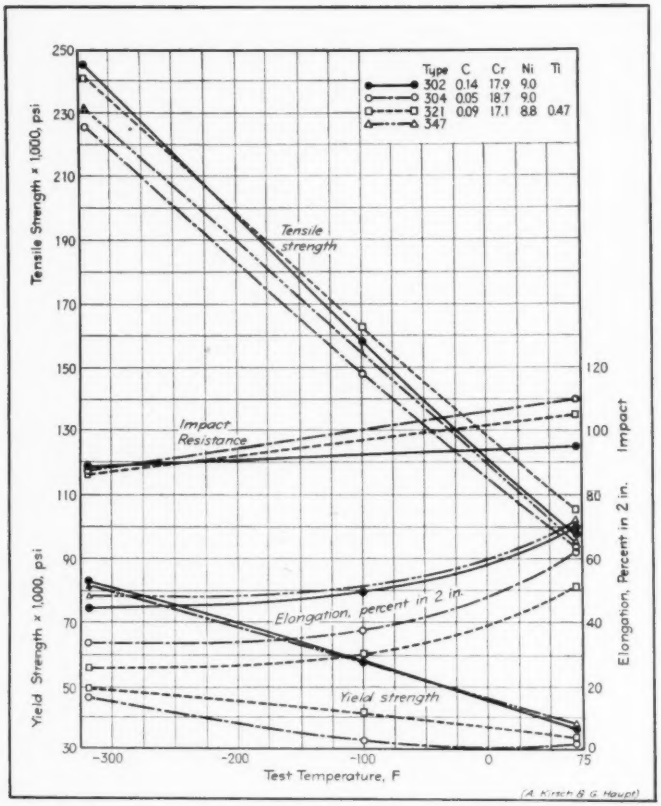

Fig. 3—Effect of temperature on the tensile properties of austenitic stainless steels of the 18-8 type. All retain 50 to 60 percent of their ductility at low temperatures, thus not indicating brittleness at tensile strengths of 225,000 psi and over.

impact resistance. Cold-worked Type 347 steel does not display any adverse effect when tested at —320 F. compared to room temperature. This is not characteristic of this heat alone, Gillett having noticed this phenomenon in other steels of the Type 347 analysis range in his investigations, which were reported in the *ASTM Bulletin*, August, 1941.

As noted in the preceding data, mechanical hardening causes a pronounced reduction of room temperature impact properties compared to properties at —320 F. It was thought the cold worked austenitic stainless steels lost toughness because of an instability in structure caused by a combination of chemistry, cold work, and temperature. When the nickel content of Type 301 is lowered to the minimum of about 6 percent as stated in the AISI specifications the alloy's composition is such that it lies close to the phase boundary between the ferrite phase and ferrite-austenitic region at room temperature, and below room temperature is entirely ferritic. Due to the poor low temperature properties of the other ferritic stainless steels, it has been postulated that these alloys would be brittle, especially since cold working also produces ferrite. To determine if this was "fact or fiction," several induction furnace heats were forged and cold drawn to full-hard tensile properties, and their impact properties were then checked at temperatures ranging from room temperature to —320 F.

The steel had the following composition: 0.12 *C*, 0.43 *Mn*, 0.57 *Si*, 17.6 *Cr*, and 6.29 *Ni*. When cold drawn to a tensile strength of 207,000 psi, the material lost little of its initial impact strength of 35 ft-lb at room temperature, decreasing to 29 ft-lb at —320 F. The higher nickel steel containing 18.29 percent chromium and 7.22 percent nickel—a definitely austenitic composition—dropped from 48 ft-lb at room temperature to 38 ft-lb at —320 F. Thus, while the overall impact strength of the low nickel material is lower, its sensitivity to low temperatures is not any greater.

Welded Austenitic Stainless Steel

Since welding is one of the most widely used methods of making joints in industrial equipment, it is obvious that any material used in industrial processing must not only be weldable, but also meet the mechanical property requirements after welding. It is desirable to meet these requirements in the "as welded" condition to eliminate heat treatment or stress relieving after fabrication. The austenitic stainless steels possess good ductility as welded, as shown in Table II. Samples used for test were machined with a 30 deg bevel and a 1/16 in. root, and then welded. The welded samples were machined to size and a keyhole notch placed in the weld metal opposite the root, the root side being struck by the anvil.

Table II—Impact Resistance of Welded Austenitic Stainless Steel

AISI Type No.	Impact Strength, Ft-lb[2]	
	Room Temperature	—320° F
304	29, 35, 35	19, 22, 23
304	56[3,4]	20[3,4]
304 (1,600 F anneal)	61[3,4]	20[3,4]
304 (1,900 F anneal)	69[3,4]	31[3,4]
309	33	18
310	34	21
316	48, 37	20, 24
347	32, 27*, 24	23*, 18, 14
347 (1,600 F anneal)	28	18, 14
347 (1,900 F anneal)	30	21

[1] Charpy keyhole specimens unless otherwise identified.
[2] All results based on an average of two or more tests.
[3] Charpy vee-notched specimens.
[4] Data from Electro-Metallurgical Corporation.

Welds made with austenitic stainless steel filler rods, regardless of base metal, have satisfactory impact resistance at low temperatures. Generally, speaking, austenitic stainless steel welds have impact resistances ranging between 25 and 40 ft-lb at room temperature and 18 and 25 ft-lb at —320 F. Different heats of Type 347 have behaved erratically at —320 F, in one instance the as-welded impact resistance being as low as 14

ft-lb. Stress relieving of Type 347 welds does not seem to improve the low temperature impact resistance; in several instances it was impaired, possibly due to aging. Fully annealing Type 347 stainless steel at 1900 F improves the room temperature impact toughness, but adversely affects toughness at —320 F. This phenomenon is important since vessels constructed according to ASME regulations sometimes require a stress relieving treatment.

The effects of long exposure in liquid nitrogen (—320 F) was investigated by Dr. Krivobok for welds in Type 304 and 310 steels. This data showed no tendency to age in one year.

Tensile Properties at Low Temperatures

The annealed austenitic stainless steels retain 50-60 percent of their ductility at —320 F when tested in tension. Fig 3 shows the effects of decreasing temperature upon the tensile properties of Types 302, 304, 321, and 347 steel. While the tensile and yield strength increase about 100 percent from room temperature to —320 F, ductility, as measured by percent elongation in 2 in., and impact resistance does not indicate brittleness even though the tensile strength is in the vicinity of 240,000 psi. Types 302 and 347, cold-drawn to ½ hard, increase in ductility when tested in tension below room temperature. This increase is probably due to the fact that the specimens do not become heated when pulled, thus allowing them to stretch uniformly over the entire gage length.

An investigation of the tensile properties of resistance seam-welded joints for annealed Type 347 and ½ hard Type 302 showed tensile strengths of 92,700 psi and 148,000 psi respectively at room temperature, and 233,000 psi and 174,800 psi at —320 F. The base metal at —320 F withstood 232,000 psi in tension and an elongation in 2 in. of 49.5 percent (Type 347) and 275,400 psi and an elongation of 20.5 percent for ½ hard (Type 302.) From these data, weld joint efficiencies of 100 percent and 63.5 percent were calculated for Type 347 and for ½ hard Type 302.

Mebs and McAdams also report that the modulus of elasticity is increased when testing in tension at low temperatures (*NACA Technical Note No. 818*, July, 1941). Other investigations by McAdams, Keiland and Cromwell showed a change in the shape of the stress-strain curve as the testing temperature decreases, indicating what appears to be a definite yield point in these steels.

Fatigue Properties at Low Temperatures

The endurance limit of Type 302 is increased as the temperature is reduced. The amount of increase does not seem to be proportional to the increase in tensile strength. Based on data by Russell which was presented at the *ASME-ASTM Symposium on Effect of Temperature on Metals*, 1931, annealed and cold drawn Type 302 stainless steel tested on an R. R. Moore endurance testing machine giving cycles of reverse bending showed an increase in endurance limit when tested at —40 F compared to room temperature results. The stress-endurance limit diagrams for these conditions are shown in Fig. 4; the dotted lines indicate that the stress was raised and the test continued. Tensile properties of the annealed material tested under the above conditions are as follows:

ANNEALED, TYPE 302: tensile strength, 88,000 psi at room temperature and 160,000 psi at —40 F; percent elongation in 2 in., 69.9 at room temperature and 48.7 at —40 F; reduction of area, 76.7 percent at room temperature and 70.2 percent at —40 F; and endurance limit, 33,000 cycles at room temperature and 42,000 at —40 F.

COLD DRAWN, TYPE 302: endurance limit, 63,000 cycles at room temperature and 76,000 cycles at —40 F.

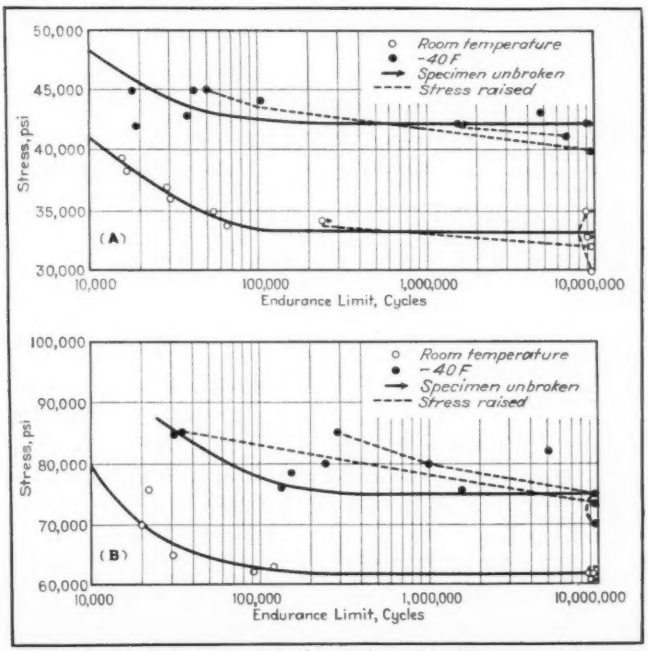

Fig. 4—Effect of temperature on the endurance limit of AISI Type 302 stainless steel: *A*, cold drawn and *B*, annealed.

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Private Correspondence from Dr. V. N. Krivobok, International Nickel Company

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Torque Reversal and Vibrations In Cyclically Loaded Systems—I

Procedure for analyzing torque reversal and vibrations in reduction gear systems subjected to cyclic loading when driven by a constant torque prime mover. General equations for natural frequencies and forced vibrations are derived and applied in the investigation and analysis of torque components and critical speeds in an assumed installation.

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TO ASSURE a smooth operating speed range, motor or turbine driven systems consisting of gearing and reciprocating units should be analyzed while in the design stage. In such systems there is a discrepancy between delivered and consumed torque; the former being constant and the latter varying periodically.

A high degree of torque variation is not required to set up and sustain torsional vibration, particularly at speeds where the frequency of the periodic torque variations coincides with the natural frequency of torsional vibration of the system. The rotating masses accelerate or decelerate as a result of the excess or insufficient torque supplied by the motor or turbine.

Because of the periodic speed changes of the masses, an alternating twist is imposed on the constant twist induced by the torque of the prime mover. If a negative net torque results at the gears during the cycle, the tooth contact will be thrown from the driving to the back face. Such a condition displays itself in noisy gear clatter and eventually leads to tooth failure.

In a reciprocating unit such as a pump or compressor, the torque variation as shown in Fig. 1 is induced by: (*a*) The inertia of the reciprocating parts, which is determined by speed, weight and geometry of the linkage; and (*b*) the fluid or gas pressure force, which is a function of load alone. The net torque effort of the unit produced by these two forces together repeats itself periodically every revolution.

The net torque equals the sum of the constant mean torque and an infinite number of periodic torques with respective frequencies of 1, 2, 3 . . . . . times the crank speed. Because of their rapidly decreasing magnitude with increasing ratio of torque frequency to crank speed, only the lower orders are of importance in practice. Because the separately determined torque components are superimposed, it is sufficient to analyze only one of such components to obtain a representative result. Furthermore, the dynamic effects induced in the most elaborate system can be analyzed in a simple basic system if their elements are similar and differ only in magnitude and phase.

Consider the two-mass basic system shown in Fig. 2. This system consists of a turbine driving a single cylinder, single acting compressor through gears; the compressor and gear are treated as a single mass. The mathematical expressions required for both the natural frequencies and forced vibrations are derived from a single analysis made for the latter and adapted to the former by placing the external torque equal to zero. The derivation follows:

Where

i_2 = mass polar moment of inertia of pinion, lb in. sec²
i'_2 = mass polar moment of gear, lb in. sec²
n = ratio of pinion rpm to gear rpm
J_1 = mass polar moment of inertia of the turbine, lb in. sec²
J_2 = mass polar moment of inertia of the gear reduction and compressor, lb in. sec²
$J_2 = i_2 + i'_2/n^2$
ϕ_1 = angular twist of turbine shaft at the turbine, radians
ϕ_2 = angular twist of turbine shaft at the pinion, radians
t = time, sec
K_1 = torsional rigidity of turbine shaft, lb in. per radian
$\dot{\phi} = \frac{d\phi}{dt}$ = first derivative of ϕ with respect to time, radians per sec
$\ddot{\phi} = \frac{d^2\phi}{dt^2}$ = second derivative of ϕ with respect to time, radians per sec²
M = maximum periodic torque, lb in.
N = shaft speed, rpm
$m = \pi N/30$ = forced circular frequency of vibrations, radians per sec
p = natural circular frequency of vibration, radians per sec
λ_1 = amplitude of torsional vibration at the turbine, radians
λ_2 = amplitude of torsional vibration at the pinion, radians

The kinetic energy E of the system is

$$E = \tfrac{1}{2}(J_1\dot{\phi}_1^2 + J_2\dot{\phi}_2^2) \quad (1)$$

and the potential energy V equals

$$V = \tfrac{1}{2} K_1 (\phi_1 - \phi_2)^2 \quad (2)$$

Substituting Eqs (1) and (2) in Lagrange's equation

$$\frac{d}{dt}\left(\frac{\partial E}{\partial \dot{\phi}}\right) - \frac{\partial E}{\partial \phi} + \frac{\partial V}{\partial \phi} = M \sin mt \quad (3)$$

the general equations of motion obtained are:

$$J_1\ddot{\phi}_1 + K_1(\phi_1 - \phi_2) = 0 \quad (4)$$

$$J_2\ddot{\phi}_2 - K_1(\phi_1 - \phi_2) = -\frac{M}{n}\sin mt \quad (5)$$

The right hand member of Eq (5) is the instantaneous equivalent torque at the pinion. Note that the twist at the pinion is opposite to that at the gear.

Substituting the values

$\phi_1 = \lambda_1 \sin mt$
$\phi_2 = \lambda_2 \sin mt$

in Eqs (4) and (5), there results

$$-J_1\lambda_1 m^2 + K_1(\lambda_1 - \lambda_2) = 0 \quad (6)$$

$$-J_2\lambda_2 m^2 - K_1(\lambda_1 - \lambda_2) = -M/n \quad (7)$$

adding Eqs (6) and (7), there results

$$m^2(J_1\lambda_1 + J_2\lambda_2) = M/n \quad (8)$$

From Eq (6)

$\lambda_2 = (1 - J_1 m^2/K_1)\lambda_1$

Substituting this value in Eq (8)

$$\lambda_1\left[1 - \frac{m^2}{K_1(J_1 + J_2)/J_1J_2}\right] = \frac{M}{n\,m^2(J_1 + J_2)} \quad (9)$$

For the natural frequency the external torque is zero and the solution is

$\phi = \lambda \sin pt$

Substituting this value in Eqs (7) and (8) modified for M equals 0

$$\frac{K_1(J_1 + J_2)}{J_1J_2} = p^2$$

which when substituted in Eq (9) gives

$$\lambda_1 = \frac{M}{n\,m^2(J_1 + J_2)}\left(\frac{1}{1 - m^2/p^2}\right) \quad (10)$$

Since the inertia of the pinion is relatively small, the alternating torque T,

*The analysis presented is the result of an investigation conducted by the author's company and in which the author took part.

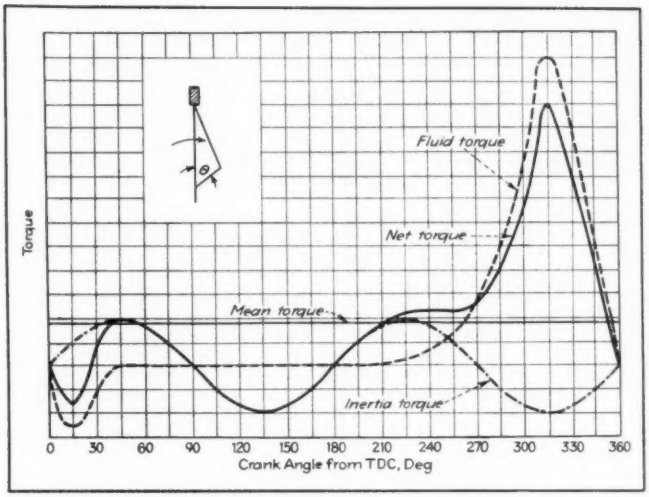


Fig. 1—Cyclical variations of net torque and its components in a reciprocating compressor. The net torque effort repeats itself periodically every revolution.

at the gears will be approximately that in the turbine shaft, or

$$T_a = K_1(\lambda_1 - \lambda_2) = J_1\lambda_1 m^2$$
$$= \frac{M}{\pi}\left(\frac{J_1}{J_1 + J_2}\right)\left(\frac{1}{1 - m^2/p^2}\right)$$
$$= \text{const.} \times \left(\frac{1}{1 - m^2/p^2}\right)$$

Thus the term

$$\frac{1}{1 - m^2/p^2}$$

called the dynamic magnifier, which is a function of the ratio of forced vibration frequency to natural frequency, determines the torque. Its value is plotted in Fig. 3 for values of m/p. When m/p is 1, the frequencies are equal, that is, the system is running at its critical speed. Note that the condition obtained at m/p equals 0 is identical with that for m/p equals $\sqrt{2}$. In the region of $0 < m/p < 0.8$ the alternating torque increases fairly slowly as m/p increases, but decreases very rapidly in the range of values greater than $\sqrt{2}$ as m/p increases.

Each of the torque components has its own critical speed, which is derived by dividing the natural frequency by the corresponding order number. At these speeds the alternating torque theoretically becomes infinite (but for the damping present in the system), therefore, the operating and critical speeds should be sufficiently removed from each other.

Criteria For Design

To obtain a sufficiently wide gap between the operating and the critical speeds, the natural frequency of the system should be increased or decreased. In increasing the frequency, the most favorable condition can be attained at m/p equals 0, for which value the torque T_a is

$$T_a = MJ_1/\pi(J_1 + J_2)$$

Thus torque is inversely proportional to the mass. This solution would result in impractical design because of the large masses and high natural frequency. Furthermore, it is always possible that high order criticals will occur close to or in the operating range, in which event a forced vibration analysis is required.

By proper selection of masses and elasticities, however, the frequency can be lowered to such a value that the operating range lies in the wide gap between two low-order resonant zones. Occasionally, all critical speeds can be placed below the operating speed, then the calculations are reduced to those for obtaining the natural frequencies, no reference being made to the effects of forced vibration.

Lowering the frequency implies either an increase in the polar moments of inertia of the oscillating members, or an increase in the flexibility of the elastic connections. Increasing the moments of inertia means an increase in overall weight, which is undesirable. The alternative method, that is, an increase in the flexibility of the elastic connections, however, can be successfully utilized.

In a system, which will be analyzed subsequently, gear torque reversal will not occur under steady load and speed, if the natural frequencies are kept at values of m/p equals 1.5. Physical limitations might require smaller values for m/p, in which event the need for a forced vibration analysis can be determined from an estimate of the harmonic torque components.

Description of Installation

Assume a typical installation, like that shown at the head of Table I, consisting of a constant speed turbine driving two compressor units through a reduction gear fitted with a double-ended shaft. Each compressor unit includes two identical 2-cylinder, 2-stage, double acting compressors with all four cylinders driven from a single crank. The compressors are of semi-radial design with low pressure cylinders mounted in V-position, each being 30 deg from the vertical centerline, and two high pressure cylinders mounted horizontally. The included angle between successive cylinders is 60 deg. The sequence of operation is:

1. All compressors unloaded. Unit idles at speed. Torque demand is equal to friction and inertia of reciprocating parts.
2. One to four compressors cut in in sequence as required by air demand.
3. The controls unload the compressors one at a time in sequence until idling is reached and the cycle is repeated.

The governor assures a ±3 percent speed change. The operating speed of the compressors is 600 rpm, that

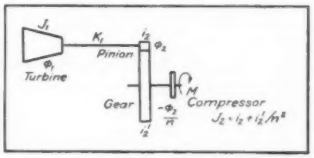


Fig. 2—Two mass basic system consisting of a turbine, gears and a single cylinder, single acting air compressor.

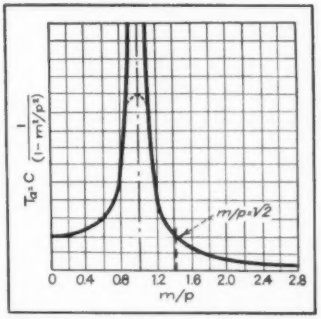
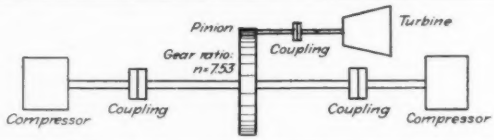
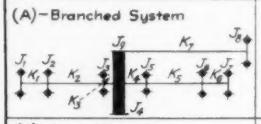
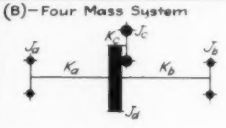
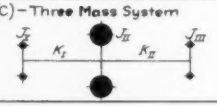
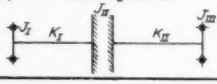


Fig. 3—Magnitude of alternating torque for different ratios of forced vibration frequency to natural frequency.

Table I—Method of Replacing a Multi-Mass System With a Nearly Equivalent One-Mass System



Equivalent Systems	Moment of Inertia of Masses, in. lb sec^2	Flexibility of Shafting, in. lb/rad 10^6	SOLUTION
(A)—Branched System 	$J_1 = J_7 = 36$ $J_2 = J_6 = 40$ $J_3 = J_5 = 19$ $J_4 = 2{,}458$ $J_8 = 44$ $J_9 = 1.05$	$K_1 = K_6 = 12.4$ $K_2 = K_5 = 6.2$ $K_3 = 41.8$ $K_4 = 16$ $K_7 = 2.36$	Tabulation Method
(B)—Four Mass System 	$J_a = J_1 + J_2 = 76$ $J_b = J_6 + J_7 = 76$ $J_c = n^2 J_8 = 2{,}495$ $J_d = J_4 + n^2 J_9 + J_3 + J_5 = 2{,}556$	$K_a = 4.48$ $K_b = 3.82$ $K_c = n^2 K_7 = 133.8$	$\omega_a^2 = K_a/J_a,\ \omega_b^2 = K_b/J_b,\ \omega_c^2 = K_c/J_c$ $F_1 = 9.55\,p_1,\ F_2 = 9.55\,p_2,\ F_3 = 9.55\,p_3$ $\left(\frac{J_d}{\omega_a^2\,\omega_b^2\,\omega_c^2}\right)p^8 - \left(\frac{J_a+J_d}{\omega_b^2\,\omega_c^2} + \frac{J_d+J_b}{\omega_a^2\,\omega_c^2} + \frac{J_c+J_d}{\omega_a^2\,\omega_b^2}\right)p^4 +$ $\left(\frac{J_d+J_b+J_c}{\omega_a^2} + \frac{J_a+J_d+J_c}{\omega_b^2} + \frac{J_a+J_d+J_b}{\omega_c^2}\right)p^2 - \left(J_a+J_d+J_b+J_c\right) = 0$
(C)—Three Mass System 	$J_I = J_a = 76$ $J_{II} = J_c + J_d = 5{,}051$ $J_{III} = J_b = 76$	$K_I = 4.48$ $K_{II} = 3.82$	$F_1 = 9.55\,p_1,\quad F_2 = 9.55\,p_2,$ $\left(J_I\ J_{II}\ J_{III}\right)p^4 - \left[J_I\ J_{II}\ K_{II} + J_{II}\ J_{III}\ K_I + \left(J_I\ J_{III}\right)\left(K_I + K_{II}\right)\right]p^2 + \left(J_I + J_{II} + J_{III}\right)K_I\ K_{II} = 0$
(D)—One Mass Systems 	$J_I = J_{III} = 76$ $J_{II} \approx \infty$	$K_I = 4.48$ $K_{II} = 3.82$	$F_1 = 9.55\sqrt{K_I/J_I}$ $F_2 = 9.55\sqrt{K_{II}/J_{III}}$

is, the speed range is between 580 rpm at full load and 620 rpm at no load condition. The gear ratio n is 7.53. Turbine output at 4520 rpm is 268 hp per compressor unit. Connection between gear and compressors is by means of flexible couplings of variable flexibility. The equivalent system of the assumed installation is shown in Fig. 4. The angle α is the phase difference between the harmonic torques acting at masses 1 and 7; that is, at the compressor units. Thus the motion at each mass is composed of two components, one resulting from each external torque. The generalized solution is

$$\phi_i = \lambda'_i \sin mt + \lambda''_i \sin (mt + \alpha)$$

The solution is simplified if it is made for the components of those torques that are exactly "in phase" or "out of phase." This method eliminates α, permitting solution of the separate effects by straight addition or subtraction. The solution can then be written as

$$\phi_i = \lambda_i \sin mt$$

consequently

$$\ddot{\phi}_i = -\lambda_i m^2 \sin mt$$

The mathematical expressions required for both the natural frequencies and forced vibrations are similar to those given in the foregoing for a basic system. In general terms Eq (8) can be written as:

$$\sum_{i=1}^{i=n} J_i \lambda_i m^2 + \sum_{i=1}^{i=n} M_i = 0 \qquad (11)$$

Similarly the general term for λ is

$$\lambda_q = \lambda_{q-1} - \left(\sum_{i=1}^{i=q-1} J_i \lambda_i m^2 + M_i\right) \Big/ K_{q-1} \qquad (12)$$

For the natural frequencies the external torques are zero, and the solution is

$$\phi_i = \lambda_i \sin pt$$

Substituting this equation in Eqs (11) and (12) modified for

$$M_1 = M_7 = 0$$

there results

$$\sum_{i=1}^{i=n} J_i \lambda_i p^2 = 0 \qquad (13)$$

and

$$\lambda_q = \lambda_{q-1} - \left(\sum_{i=1}^{i=q-1} J_i \lambda_i p^2\right) \Big/ K_{q-1} \qquad (14)$$

In the determination of forced vibration and natural frequencies Eqs (11) and (12), and Eqs (13) and (14), are used respectively. Since m^2 is a known value for any harmonic torque, the solution for vibratory torques is direct. The solution for natural frequencies, however, requires the determination of all p^2 values that satisfy Eq (13). While the roots of this equation can be established by trial and error, it is desirable to estimate these in advance before checking by tabulation. Approximations that make such estimates possible are discussed in the next section.

Natural Frequency Calculations

The assumed system shown in diagrammatic form at the head of Table I can be replaced by an equivalent 3 branch system of 9 masses, Table I(A). This 3 branch system consists of two gear-compressor branches and one turbine-pinion branch, joined together at the gear.

Much arithmetical work can be avoided by applying shorter methods to approximately equivalent systems, thus establishing frequency values for

use in frequency tables. The system can be reduced to one of 4 masses, Table I(*B*), by adding the coupling hubs to the gear and the compressor masses respectively, and replacing the turbine-pinion branch by one rotating at compressor speed. Since the torsional rigidities of the gear and compressor shafts are large compared with that of the coupling, this simplification introduces little error.

Since the equivalent torsional rigidity of the turbine-pinion shaft is large compared with the rigidity of the shafts between the gear and the compressors, the turbine and gear can be taken as one mass, Table I(*C*), thus reducing the original 9 mass system to one of 3 masses.

A further simplification is possible because of the large ratio of gear to compressor mass. This simplification results in two single mass systems, Table I(*D*), the frequencies for which correspond closely to the two frequencies of the 3 mass system, since the center mass may be regarded as infinite.

Mass and elasticity data for the various equivalent systems together with the applicable natural frequency formulas are given in Table I, where the simplified equivalent systems are shown in the order obtained.

The actual reduction is made as follows:

(a) Equating the kinetic and strain energies in the original and the equivalent shafts, there results

$$J_e = n^2 J \qquad \text{or} \quad K_e = n^2 K$$

(b) Two masses replaced by a single mass, see Fig. 5(*A*),

$$\frac{1}{K_1} = \frac{1}{K_a} + \frac{1}{K_b}$$

or

$$l_1 = l_a + l_b$$
$$J_1 l_a = J_2 l_b$$

or

$$l_a = J_2 l_b / J_1 = l_1 - l_b$$

consequently

$$l_b = J_1 l_1 / (J_1 + J_2)$$
$$K_b = K_1 (J_1 + J_2)/J_1 \qquad (15)$$

(c) Several elasticities replaced by a single elasticity, see Fig. 5(*B*),

$$\frac{1}{K} = \frac{1}{K_1} + \frac{1}{K_2} + \frac{1}{K_3} + \ldots\ldots (16)$$

After a 3-mass system, Table I(*C*), and two single mass systems, Table I(*D*), have been obtained, the first two frequencies can be estimated; or a 4-mass system, Table I(*B*), can be used for estimating the first three frequencies. While all three can be obtained from the 4-mass system, it is simpler to use the latter for the third alone, employing values for the first two from the simpler systems. This condition results from the complexity of the 4-mass equation, which is of the form

$$Ax^3 - Bx^2 + Cx - D = 0 \qquad (17)$$

By rewriting Eq (17) there is obtained

$$x^3 - \frac{B}{A}x^2 + \frac{C}{A}x - \frac{D}{A} = (x - p_1^2)(x - p_2^2)(x - p_3^2)$$
$$= x^3 - (p_1^2 + p_2^2 + p_3^2)x^2 + (p_1^2 p_2^2 + p_1^2 p_3^2 + p_2^2 p_3^2)x - p_1^2 p_2^2 p_3^2 = 0 \qquad (18)$$

by equating coefficients, three different equations are obtained, each one giving a fairly close solution. This method applied to the 4-mass system in Table I(*B*) results in

$$\frac{D}{A} = \frac{(J_a + J_b + J_c + J_d)/J_d}{\omega_a^2 \omega_b^2 \omega_c^2} = \left(\frac{J_a + J_b + J_c + J_d}{J_a J_b J_c J_d}\right) K_a K_b K_c$$
$$= p_1^2 p_2^2 p_3^2 = \text{constant} \times p_3^2 \qquad (19)$$

After the approximate frequencies are determined by these methods, tabular means are then used to determine the exact torsional characteristics of the original system.

Tabulation Method

The tabulation consists of a step method for evaluating Eq (13) for selected values of p^2. When this sum equals zero, the corresponding p^2 value gives a natural frequency equivalent to

$$f = \frac{60p}{2\pi} = 9.55p \text{ cycles per min}$$

In a geared system consisting of several branches connected at a common junction point, a separate table is required for each branch. Since in a vibrating system at resonance the amplitudes can attain any value, the values of the amplitudes λ of vibration are purely relative and have no quantitative significance. Thus any one of the branches can be selected as the basic branch with unity amplitude λ_1, assumed for the mass at its free end. The amplitudes of all other masses are then determined in terms of λ_1. In the installation being investigated, the shorter of the two gear-compressor branches is selected as basic. The various columns in the table contain in sequence values for

(1) J = mass polar moment of inertia of each mass, lb in. sec²
(2) Jp^2 = torque per unit deflection at each mass, lb in. per radian
(3) λ = torsional deflection of each mass in terms of λ_1, radians
(4) $Jp^2\lambda$ = vibratory inertia torque of mass, lb in.
(5) $\Sigma Jp^2\lambda$ = summation of the inertia torques tabulated in the previous column, lb in.
(6) K = flexibility between masses, lb in. per radian
(7) $\frac{\Sigma Jp^2\lambda}{K}$ = change in torsional deflection between successive masses, radians

The torsional deflection at each mass

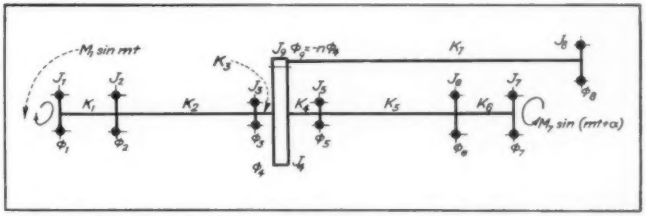


Fig. 4—Equivalent system for assumed installation consists of turbine, gear reduction, and two compressors. Angle α is phase difference between torques at compressor units.

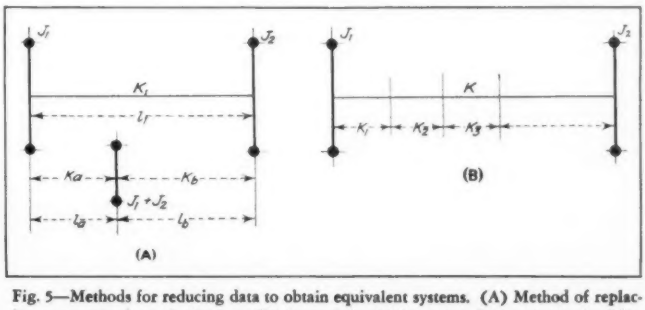


Fig. 5—Methods for reducing data to obtain equivalent systems. (A) Method of replacing two masses by a single mass. (B) Several elasticities replaced by a single elasticity.

Table II—Frequency Tabulation for 2 Node Condition

F_2 = 2,405 vibrations per min p_2^2 = 63,448

		1	2	3	4	5	6	7
	Mass	J, lb in. sec^2	Jp^2, $\frac{\text{lb in.}}{\text{rad}}\times 10^6$	λ, radians	$Jp^2\lambda$, lb in. 10^6	$\Sigma Jp^2\lambda$, lb in. 10^6	K, $\frac{\text{lb in.}}{\text{rad}}\times 10^6$	$\Sigma Jp^2\lambda/K$, radians
Basic Branch	1	36	2.2841	1	2.2841	2.2841	12.4	0.1842
	2	40	2.5379	0.8158	2.0704	4.3545	6.2	0.7023
	3	19	1.2055	0.1135	0.1368	4.4913	41.8	0.1074
	4	2,458	155.955	0.0061	0.9513	5.4426		
		where $\lambda = 0.0061$, and $T_1 = 5.4426$						
Second Branch	7	36	2.2841	α	2.2841α	2.2841α	12.4	0.1842α
	6	40	2.5379	0.8158α	2.0704α	4.3545α	6.2	0.7023α
	5	19	1.2055	0.1135α	0.1368α	4.4913α	16	0.2807α
				-0.1672α				
		Thus, $-0.1672\alpha = 0.0061$, or $\alpha = -0.0365$, and $T_2 = -0.0365 \times 4.4913 = -0.1639$						
Third Branch	8	44	2.7917	β	2.7917β	2.7917β	2.36	1.1829β
	9	1.05	0.0666	-0.1829β	-0.0122β	2.7795β		
		Thus, $-0.1829\beta = -7.53 \times 0.0061$, or $\beta = 0.2510$, and $T'_3 = -7.53 \times 0.2510 \times 2.7795 = -5.2533$						

Check: $\Sigma T = T_1 + T_2 + T'_3 = 5.4426 - 0.1639 - 5.2533 = 0.0254$ lb in. 10^6

Table III—Frequency Tabulation for 3 Node Condition

F_3 = 384 vibrations per min p_3^2 = 1,617.04

		1	2	3	4	5	6	7
	Mass	J, lb in. sec^2	Jp^2, $\frac{\text{lb in.}}{\text{rad}}\times 10^6$	λ, radians	$Jp^2\lambda$, lb in. 10^6	$\Sigma Jp^2\lambda$, lb in. 10^6	K, $\frac{\text{lb in.}}{\text{rad}}\times 10^6$	$\Sigma Jp^2\lambda/K$, radians
Basic Branch	1	36	0.0582	1	0.0582	0.0582	12.4	0.0047
	2	20	0.0323	0.9953	0.0321	0.0903	0.086	1.0500
	3	22	0.0356	−0.0547	−0.0019	0.0884	41.8	0.0021
	4	2,458	3.9747	−0.0568	−0.2258	−0.1374		
		where $\lambda = -0.0568$, and $T_1 = -0.1374$						
Second Branch	7	36	0.0582	α	0.0582α	0.0582α	12.4	0.0047α
	6	20	0.0323	0.9953α	0.0321α	0.0903α	0.086	1.0500α
	5	22	0.0356	-0.0547α	-0.0019α	0.0884α	16	0.0055α
				-0.0602α				
		Thus, $-0.0602\alpha = -0.0568$, or $\alpha = 0.9435$, and $T_2 = 0.0884 \times 0.9435 = 0.0834$						
Third Branch	8	44	0.0711	β	0.0711β	0.0711β	K	$0.0711\beta/K$
	9	1.05	0.0017	$-\beta x$	$-0.0017\beta x$	$(0.0711 - 0.0017x)\beta$		
		where $x = \frac{0.0711}{K} - 1$						
		Thus, $-\beta x = -7.53\ (-0.0568) = 0.4277$, or $\beta = -0.4277/x$						

$T_1 + T_2 + T'_3 = -0.1374 + 0.0834 + 7.53\ (0.0711 - 0.0017x)\ 0.4277/x = 0$

$0.0595x = 0.2290$, or $x = 3.8487$

Consequently, $0.0711/K - 1 = 3.8487$, and $K = 0.01466$ 10^6 lb in. per radian

is obtained by subtracting the change in deflection in column (7) from the value for the preceding mass in column (3) in accordance with Eq (14).

The basic branch in Table II, terminates at the junction point and lists both specific amplitude and torque at the junction produced by a unit deflection at the free end of this branch. The term T_1 is used to denote the torque resulting from the vibration of all masses on this branch.

For the second branch, that is, from the second compressor to the gear, an amplitude α at the free end is assumed. This branch in Table II then gives the amplitude at the junction as a function of α. By equating the corresponding amplitudes at this point, α is found in terms of λ_5, and the specific torque T_2 for this branch can then be calculated.

The third branch in Table II, the turbine-pinion branch, is similarly obtained by assuming an amplitude β at the free end of the branch and equating values at the junction point. Because of the speed difference between the basic and the third branch, the junction amplitude for the latter must be multiplied by the negative gear ratio. This same ratio must be applied to the specific torque T_3, giving $-nT_3$ equals T'_3 referred to the basic branch.

In accordance with Eq (13), if the p^2 value selected corresponds to one of the natural modes of vibration of the system, there will be no residual torque acting on the system or

$$\sum_{i=1}^{i=n} J_i\lambda_i p^2 = \Sigma T = T_1 + T_2 + T'_3 = 0$$

In the frequency tabulation for the two node condition, Table II, the fact that the amplitudes at the junction point are equal is used to determine α and β with the help of the arbitrarily selected unit amplitude at the beginning of the basic branch. The total residual torque is almost zero, consequently 2405 is the two node frequency; only a frequency expressed in decimals would lead to exactly zero residual torque. As seen from Table II, the nodal points are between masses 4 and 5, and 8 and 9 respectively.

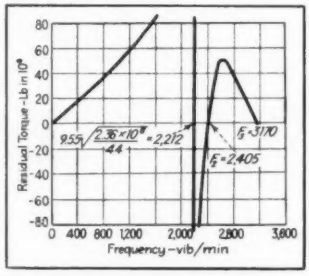


Fig. 6—Residual torque for a range of assumed frequencies.

When it proves necessary to revise a system to obtain a desired frequency, the mass or flexibility to be changed is entered into the tables as unknown and Eq (13) applied, thus determining the proper mass or flexibility required. The effectiveness of this method is demonstrated by a calculation made to determine the necessary flexibility in the turbine-pinion branch for a low three-noded frequency, see Table III.

This method has general application. Any unknown mass or flexibility can be determined to give a selected frequency value. In making the calculations, it must be remembered that:

(*a*) Amplitudes at the junction point are equal, and (*b*) residual torque at the junction is zero.

The work in the trial and error process can be reduced by plotting the residual torque versus assumed frequencies as in Fig. 6. The points where the residual torque curve crosses the abscissa are the required frequency values for p^2. Thus with two or three trials the correct value can be found. In the system being investigated, calculations for the one-noded frequency show that the residual torque at the junction increases rapidly in value as the frequency is approached, but has opposite signs above and below the frequency point, that is, the residual torque curves are asymptotic.

The largest part of the residual torque for this mode is contributed by the turbine branch of the system, indicating that the node is at the gear reduction. There is no unique solution for amplitude and torque in this case. Because of the small amplitudes in the remaining branches, a practical way to deal with this drive is to consider the turbine branch alone. A second approximation is to use the equivalent 7 mass system and solve for the first frequency by tabulation Table IV. The values obtained by both methods are practically identical.

For the higher modes a positive residual torque indicates that the assumed frequency is too high for the two-node but too low for the three-node vibration.

Without further investigation it can be stated that, in a system of the calculated natural frequencies, important resonant zones would occur within the operating speed range, and in addition as it will be shown later, torque reversal will be induced for various order harmonics. It will be necessary, therefore, to revise the assumed system in order to come closer to the m/p equals 1.5 design criteria.

By plotting the relative amplitudes of vibration, Fig. 7, the normal elastic curves, or nodal diagrams, are obtained. In the assumed system the fundamental frequency has its node close to the gear. For the second frequency, there is one node in the turbine branch between the pinion and the coupling, and one in the longer gear shaft between the gear and the flexible coupling. The third frequency has one node in each of the flexible couplings and a third between turbine and coupling. The following conclusions can be deduced from these curves:

A. The first two modes of vibration have their nodes very close to the gear, consequently any change in gear mass will have little effect on these frequencies, since the nodes are points of zero amplitude. Mass changes are most effective at points of large amplitude, and flexibility changes at points of maximum torque, that is, at the nodes.

B. Because of the relatively large amplitudes in the first and second branches, for the first two frequencies the most effective changes are those of mass at the compressors, or in flexibility of the couplings.

C. For the third frequency, because of the large amplitudes in the turbine branch, changes in this portion become most effective.

Since there are several modes of vibration, each with a different frequency, it is sometimes difficult to avoid all of the corresponding critical speeds by a single change in mass or elasticity, therefore, in such instances a careful investigation is necessary. Examination of the normal elastic

Table IV—Frequency Tabulation for 1 Node Condition

(Equivalent 7-Mass System)
$F_1 = 2,218$ vibrations per min. $p_1^2 = 53,925$

	1	2	3	4	5	6	7
Mass	J, lb in. sec²	Jp^2, $\frac{\text{lb in.}}{\text{rad}} \times 10^6$	λ, radians	$Jp^2\lambda$, lb in. 10^6	$\Sigma Jp^2\lambda$, lb in. 10^6	K, $\frac{\text{lb in.}}{\text{rad}} \times 10^6$	$\Sigma Jp^2\lambda / K$, radians
1	36	1.9413	1	1.9413	1.9413	12.4	0.1566
2	40	2.1570	0.8434	1.8192	3.7605	6.2	0.6065
3	19	1.0246	0.2369	0.2427	4.0032	41.8	0.0958
4	5,013	270.3260	0.1411	38.1430	42.1462	16.0	2.6341
5	19	1.0246	−2.4930	−2.5543	39.5919	6.2	6.3858
6	40	2.1570	−8.8788	−19.1516	20.4403	12.4	1.6484
7	36	1.9413	−10.5272	−20.4365	0.0038	.....	.....

Note: Adding the equivalent mass moment of inertia of the turbine and pinion at the gear to the mass moment of inertia of the gear reduces the original 9 mass system to one of 7 masses. The equation used is

$$J_4' = J_4 + n^2 (J_5 + J_6) = 2,458 + 7.53^2 (44 + 1.05) = 5,013$$

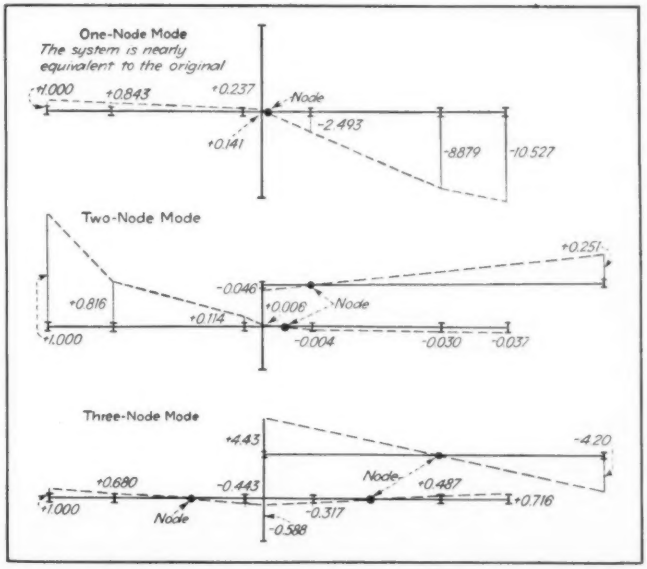


Fig. 7—Nodal diagrams, or the normal elastic curves, for three nodes obtained by plotting the relative amplitudes of vibration of the masses in the system.

curves will guide the choice of the particular method applied in any given problem.

If an existing installation must be revised for torsional vibration reasons, space limitations may prevent the use of large additional masses. In such cases, changes in flexibility alone may prove effective in providing safe operating speeds. In one actual installation, similar to the assumed installation being investigated, the nodes occurred in the flexible couplings, and this solution formed the basis for selecting very flexible couplings of the rubber-in-shear type. With the latter, practically all of the flexibility between gear and compressors is concentrated in the couplings, making these the controlling factors for natural frequency.

The frequency values determined by the various methods are compiled in Table V for all attempted solutions.

Reference

"Practical Solution of Torsional Vibration Problems, Vol. I," second edition, by W. Ker Wilson, John Wiley & Sons, Inc.

EDITOR'S NOTE: Part II of this article will be presented in the May number of PRODUCT ENGINEERING. Part II will discuss the analysis and procedure for calculating the effects of forced vibration produced by the periodically varying load torque; harmonic torques resulting from the gas pressure and reciprocating inertia forces will be calculated for the assumed turbine driven air compressor installation.

Table V—Summary of Frequency Tabulations

In the data column the mass moment of inertia values are given in lb in sec² and the flexibility values in lb in/rad. Other data are as in the original system.

	System	Natural Frequencies, vib./min. 1st Node	2nd Node	3rd Node	Data	Remarks
A	Original	2,218	2,405	3,170	Given in Table I	1st Node frequency calculated as 7 mass system
B	As A, but couplings in gear-compr. branch replaced by stiff ones and flywheels added close to compressors	2,790	3,200	4,060	$J_2 = J_6 = 16.6 + 60 = 76.6$ $J_3 = J_5 = 18$ $K_2 = K_5 = 65.5 \times 10^6$	Stiff couplings increase the frequencies introducing 5th and 7th order criticals
C	Couplings unchanged, but flywheels added to the original system close to compressors	809	934	3,151	$J_2 = J_6 =$ $40 + 582 = 622$	Changing mass alone would require very large flywheels leading to impractical design
		400			$40 + 2715 = 2,755$	
D	Medium soft couplings replacing the original ones. Flywheels added	275	308	3,110	$J_2 = J_6 = 40 + 582 = 622$ $J_3 = J_5 = 19$ $K_2 = K_5 = 0.565 \times 10^6$	Design criteria satisfied, but eliminating the flywheels would be advantageous
E	Couplings as in D or softer yet, flywheels eliminated completely	780	800	3,110	$K_2 = K_5 =$ 0.565×10^6	Results indicate that using more flexible coupling will lead to acceptable frequencies
		401	407	3,100	0.136×10^6	
F	Using very flexible couplings in the gear-compressor branches	373	377	3,106	$J_2 = J_6 = 20$ $J_3 = J_5 = 22$ $K_2 = K_5 = 0.086 \times 10^6$	Results satisfying the design criteria. Torque reversal completely eliminated
G	As F, but coupling in turbine-pinion branch replaced by a very flexible one			384	$K_7 = 0.0147 \times 10^6$	The frequency was assumed and the corresponding flexibility calculated.

Magnetic Field Patterns Around Recording Wire Studied

IN BOTH INPUT AND OUTPUT mechanisms of electronics digital computers, data in the form of coded pulses are commonly stored in magnetic media such as wire or tape. To conserve space, it is necessary that the maximum number of pulses be recorded in each linear inch without loss of distinctness or objectionable blending of one pulse with another. Investigations were made at the Bureau of Standards regarding the magnetizing current, pulse width, and frequency as related to this blending, using wire as the recording medium.

When a moving wire is magnetized in the recording head by a magnetic field produced by current pulses of a few microseconds duration, a series of small permanent magnets is produced. To minimize the effect of wire speed on the length of the magnet, speeds not in excess of 8 to 12 in. per sec were used. This meant that during the period of the magnetizing pulse, the wire moved only 0.0001 to .0002 inch.

Since the dimensions of the cylindrical magnets are very small (0.005 in. in diameter by 0.010 in. long) and the magnetic forces encountered extremely weak, considerable care must be exercised to obtain the field pattern. Techniques were developed for mounting the wire, producing the patterns, and photographing the wire pattern.

The wire is magnetized by current pulses with a standard commercial recording head. The conductor is tightly stretched across the surface of a clean glass plate and few drops of melted shellac used to cement the wire to the plate at two points approximately 3 in. apart. The glass plate with the attached wire is then placed on the stage of a standard contour-measuring projector. The illuminated image of the wire is projected onto a vertical ground-glass screen at a magnification of 150 diameters by a lens and mirror system. After the pattern is formed, the ground-glass plate is replaced with film and the pattern photographed.

A drop of light oil containing carbonyl iron particles in suspension is placed on the wire and the resulting formation of the pattern observed. If oil of the correct density and viscosity has been selected for the size and shape of the iron particles, the particles settle at the proper rate to give a definite and distinct pattern of the external field. Particles in the strongest field (near the wire) are attracted and adhere to the magnetized portion of the wire, and in a few minutes build up a pattern extending out a distance approximately one-half the diameter of the wire. The pattern on the glass forms more slowly since the magnetic forces acting there are much smaller.

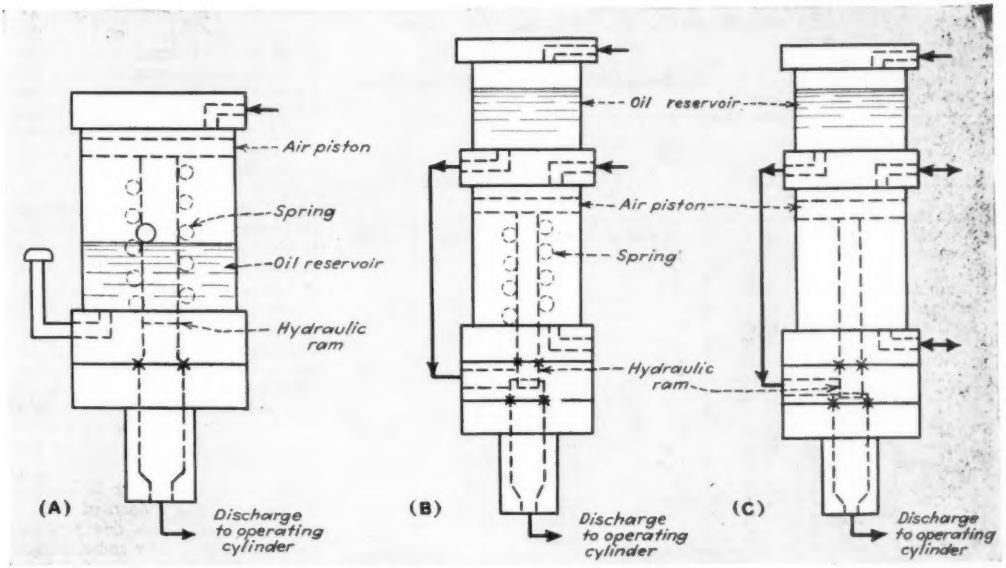


Fig. 1—Two basic types of boosters. The unit at (A) is a single acting, spring return unit for use in single pressure circuits. The units at (B) and (C) can be driven either by air or oil, and used either in single or dual pressure systems. The unit at (B) is single acting, while that at (C) is double acting; the oil reservoir may be attached to the booster or mounted separately.

Fluid Pressure Boosters

Air and oil operated boosters for producing fluid pressures up to 2,000 psi or more. Recommended circuits and applications.

FRANK FLICK
Chief Engineer, Miller Motor Company
Chicago

A BOOSTER, sometimes known as an intensifier, is an air or oil driven device that takes oil at atmospheric pressure and increases its pressure to a higher value. This is accomplished by connecting an air or hydraulic cylinder of a specified bore and stroke to a hydraulic ram of smaller diameter. The increased pressure generated in the booster is then used to drive a separate work cylinder.

Boosters are used primarily to save space or weight. They generally are less costly and more efficient than pumps, and are more satisfactory in operations involving high speed or the holding of pressure. As a result, they are being used to supply the necessary hydraulic pressure for performing such operations as punching, clamping, shearing, riveting, and pressing sheet metal and plastic materials. In some circuits, boosters also are better adapted to controlled speed than direct air cylinders, and are being applied because of this characteristic.

In most boosters, the piston rod of the air cylinder serves as the hydraulic ram, as shown in Fig. 1. When air pressure is applied to the piston, it forces the fluid under high pressure into the hydraulic work cylinder. The return stroke of the booster is accomplished either by spring action (single acting boosters) or by air action (double acting boosters).

Spring return boosters require no air on the return stroke, but lose some power when compressing the spring. A three way valve, instead of the four way valve required in a double acting booster circuit, can be used with a consequent saving in first cost. However, a spring return booster is longer than a double acting booster by an amount equal to the length of stroke because of the housing required for the spring and this may prove undesirable when space is at a premium.

In double acting boosters, the input pressure drives the booster on both its working and return strokes. They therefore require almost twice as much air as is necessary for a single acting unit. If air is in critical supply, nearly all of the air used on the return stroke may be saved by using a five way valve so that the piston can be returned with low pressure air.

The booster shown at *A* in Fig. 1 is a single-acting, spring return unit. It has an oil reservoir in the cylinder proper between the air piston and the end of the hydraulic ram. Breather holes are located in the side of the air cylinder tubing. Boosters of this type are used in single pressure systems only, and are always air operated.

Another type of booster is illustrated at *B* and *C* in Fig. 1. It may be either a single acting or double acting unit. It may be driven either by air or by hydraulic pressure. With either of these actions or driving mediums, it can be used in either single or dual pressure systems. The oil reservoir may be attached to the unit or mounted separately.

When used in a dual pressure circuit, this booster uses only about 5 per cent of the compressed air that would be consumed on a job if it were done by a single pressure booster or by an

Table I—Booster Selector Chart

Theoretical Hydraulic Ram Pressure at Input Pressures of		Theoretical Booster Ratio	Driven Hydraulic Ram		Driving Cylinder	
80 psi	100 psi		Dia	Area (sq in.) or Volume (cu in.) per in. of stroke (Vb)	Dia	Area
1	2	3	4	5	7	6
846	1057	10.57	1"	0.785	3¼"	8.296
447	559	5.59	1⅜"	1.485		
276	345	3.45	1¾"	2.405		
211	264	2.64	2"	3.142		
1280	1600	16.00	1"	0.785	4"	12.566
680	850	8.50	1⅜"	1.485		
416	520	5.20	1¾"	2.405		
320	400	4.00	2"	3.142		
208	260	2.60	2½"	4.900		
2000	2500	25.00	1"	0.785	5"	19.635
1058	1322	13.22	1⅜"	1.485		
653	816	8.16	1¾"	2.405		
500	625	6.25	2"	3.142		
320	400	4.00	2½"	4.900		
222	278	2.78	3"	7.069		
163	204	2.04	3½"	9.621		
1523	1904	19.04	1⅜"	1.485	6"	28.274
941	1176	11.76	1¾"	2.405		
720	900	9.00	2"	3.142		
462	577	5.77	2½"	4.900		
320	400	4.00	3"	7.069		
235	294	2.94	3½"	9.621		
180	225	2.25	4"	12.566		
2708	3385	33.85	1⅜"	1.485	8"	50.265
1672	2090	20.90	1¾"	2.405		
1280	1600	16.00	2"	3.142		
821	1026	10.26	2½"	4.900		
569	711	7.11	3"	7.069		
418	522	5.22	3½"	9.621		
320	400	4.00	4"	12.566		
253	316	3.16	4½"	15.904		
205	256	2.56	5"	19.635		
170	212	2.12	5½"	23.758		
2613	3266	32.66	1¾"	2.405	10"	78.54
2000	2500	25.00	2"	3.142		
1282	1603	16.03	2½"	4.900		
889	1111	11.11	3"	7.069		
653	816	8.16	3½"	9.621		
500	625	6.25	4"	12.566		
395	494	4.94	4½"	15.904		
320	400	4.00	5"	19.635		
265	331	3.31	5½"	23.758		
2880	3600	36.00	2"	3.142	12"	113.10
1846	2308	23.08	2½"	4.900		
1280	1600	16.00	3"	7.069		
940	1175	11.75	3½"	9.621		
720	900	9.00	4"	12.566		
569	711	7.11	4½"	15.904		
461	576	5.76	5"	19.635		
381	476	4.76	5½"	23.758		
2514	3142	31.42	2½"	4.900	14"	153.94
1742	2178	21.78	3"	7.069		
1280	1600	16.00	3½"	9.621		
980	1225	12.25	4"	12.566		
774	968	9.68	4½"	15.904		
627	784	7.84	5"	19.635		
518	648	6.48	5½"	23.758		

air cylinder acting directly on the work. This economy is based on being able to operate the hydraulic work cylinder through a long approach stroke at low pressure, and using the pressure booster for the short high-pressure working stroke. Air is introduced into the top of the oil tank, thus forcing the oil through the booster and into the cylinder at ordinary line pressure. This action continues until the hydraulic cylinder encounters resistance. Air then is applied to the booster piston either through a manually operated air valve or an automatically operated air-sequence valve. As the hydraulic ram of the booster moves forward, it automatically seals off the low pressure oil line and produces the required high pressure. A circuit of this type is illustrated in Table II. This permits use of a much smaller booster than if high pressure fluid were used for the entire stroke.

This same principle can be applied to boosters that are operated with a hydraulic fluid. With this arrangement, a smaller booster and a smaller pump can be used to produce fast, long approach strokes and short, high pressure working strokes. Such a hydraulically operated unit is particularly adaptable to requirements of the plastic industry for the operation of molding presses.

Booster Benefits

Recapitulating, then, the principal reasons for applying boosters may be summarized as follows:

1. To save weight or space. In a portable device, booster operated cylinders may perform operations that would require air cylinders ten times as large and as heavy.

2. To hold pressure indefinitely without motion or heat in applications such as shown in Fig. 2. Seal-type booster can be used to advantage as a substitute for a pump on most simple circuits requiring a small to medium volume of high pressure oil per cycle. All pumps, except the more expensive variable-delivery type, must continue to pump and by-pass oil as long as pressure is held, which is undesirable because of the excessive heat that is developed.

3. To permit high speed operation in applications that otherwise would require a large pump or an accumulator in a normal hydraulic circuit. Operating speeds range from 50 to 450 strokes per min, depending on the cylinder diameter, length of stroke, and arrangement of the valving and piping.

4. To lower costs. Ordinarily, a complete booster circuit, including valves, costs less than a pump to perform the same work because manufac-

turing costs are kept low by the use of standard cylinder parts for units of different sizes.

5. To obtain wide variations of pressures and strokes. Air operated boosters are built in various sizes and ratios to supply thrusts of 500 to 5,000 psi when operated off of low pressure air lines of 20 to 200 psi. Volumes per stroke range from a few to 300 cubic inches.

6. To reduce air consumption. A booster connected for dual pressure operation saves up to 95 per cent of the air that would be consumed in operating with direct air power on applications having long approach strokes and short high-pressure working strokes.

Booster Selection

Since booster drives a hydraulic cylinder, the first step in selecting a unit for a particular application is to determine the size of the cylinder that the booster is going to operate and thus the volume of oil required. To do this, it is necessary to determine the amount of force that the cylinder must exert, and the distance through which it must move. These can be estimated from the nature of the operation that must be performed. Then let

A_a = Area of booster air piston.
A_b = Area of booster ram.
A_c = Area of work cylinder.
F = Force exerted by the work cylinder.
P_b = Booster output pressure.
P_a = Booster input pressure.
V_{chp} = High pressure working volume of work cylinder.
V_{clp} = Low pressure approach volume of work cylinder.
$V_b = A_b$ = Volume of booster ram per in. of stroke.
S_{bhp} = Length of booster stroke required to operate high pressure working stroke of work cylinder.
S_{blp} = Length of booster stroke to operate low pressure approach stroke of work cylinder.
S_{clp} = Length of a low pressure approach stroke of work cylinder.
S_{chp} = Length of high pressure working stroke of work cylinder.

Then, since the force to be exerted by the work cylinder, and the length of the approach and working strokes are known, the required area of the working cylinder can be determined by the formula

$$A_c = \frac{F}{P_b} \qquad (1)$$

At this point it is necessary to tentatively select the booster output pressure, keeping in mind that higher pressures generally require a less expensive booster and a smaller work cylinder. A booster circuit does not experience the high surge pressures that are common to most hydraulic systems, and therefore can be operated at somewhat higher pressures; however, extremely high pressures complicate the design and sealing problems of the circuit. Operating pressures of 800 to 2,000 psi are best for general purposes. When the required cylinder area and dia have been determined, the area of a standard work cylinder closest to the calculated value can be substituted in Eq 1 and the exact operating pressure calculated.

Since the booster output pressure P_b has been determined and the air supply pressure is known, the booster ratio can be determined. The booster ratio is the ratio of the booster output pressure to the input pressure. The air supply pressure is taken as the net line pressure at the booster input valve, after allowance is made for pressure drop and fluxuations in the supply line between the compressor and the most distant line outlet where the booster might be located.

$$\text{Booster ratio} = \frac{P_b}{P_a} = \frac{A_a}{A_b} = \frac{A_a}{V_b} \qquad (2)$$

Booster ratios for all standard size boosters are shown in Column 3 of the booster selector chart, Table I. The same or approximately the same booster ratio appears many times but the volumn per in. of stroke varies. It therefore is necessary to select a booster that will deliver the volume of oil required by the working cylinder.

The volume of oil required for the high pressure stroke of the work cylinder equals:

$$V_{chp} = A_c \text{ by } S_{chp} \qquad (3)$$

The volume of oil required for the approach stroke of the cylinder equals:

$$V_{clp} = A_c \text{ by } S_{clp} \qquad (4)$$

The length of booster stroke required to operate the high pressure stroke of the cylinder is expressed as follows:

$$S_{bhp} = \frac{V_{chp}}{V_b} \qquad (5)$$

The length of booster stroke required to operate the low pressure

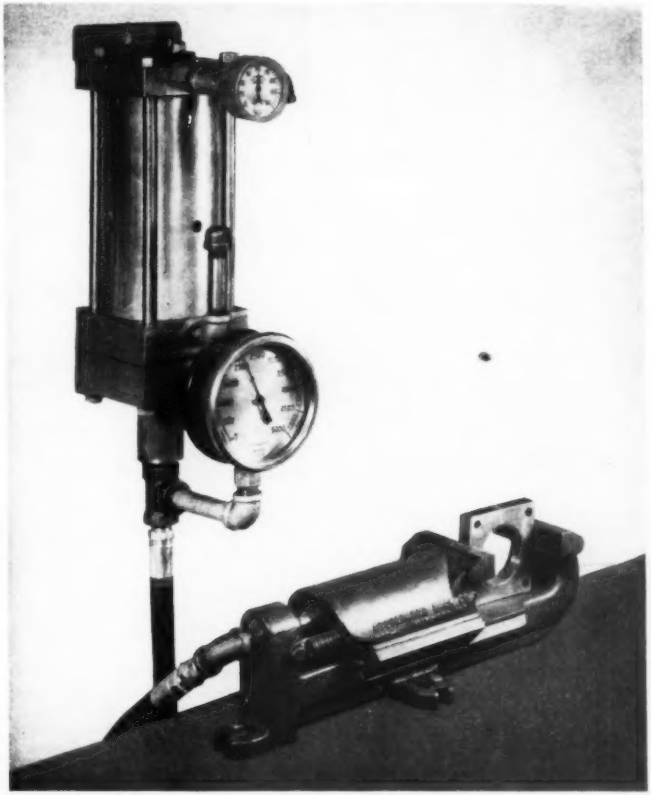


Fig 2—Air operated booster and hydraulic work cylinder used for clamping. A system of this type holds pressure indefinitely without generating heat.

approach stroke of the work cylinder is

$$S_{blp} = \frac{V_{clp}}{V_b} \qquad (6)$$

When selecting V_b the designer should use the approximate booster ratio previously determined from input and output pressure, and of course, the same value of V_b must be substituted in both Eq 5 and Eq 6. For most economical first cost use the smallest value of V_b that will give the required volume should be used.

The volume of oil required by the work cylinder can be furnished by a small or medium volume per in. of stroke booster with a long stroke, or by a large volume per in. of stroke booster with a short stroke. It generally is best to avoid extremely long strokes. For rapid cycling or fast operation, boosters with strokes less than 10 in. should be used whenever possible. If the calculated stroke is too long for the application, it may be necessary to tentatively select another size of booster and recalculate the entire problem; it is obvious that the problem becomes one of trial and error to obtain the best size. In all instances, several in. should be added to the calculated stroke to make up for stretch in the pipe lines, for foaming, and for other contingencies.

Single Versus Dual Pressure Circuits

Boosters with single pressure circuits are generally used when the approach stroke of the hydraulic cylinder is short, and especially when it is short in comparison to the high pressure working stroke. Boosters with dual pressure circuits are generally used when the approach stroke of the hydraulic cylinder is long, and especially when it is long in comparison to the high pressure working stroke. The advantages and limitations of various booster circuits are given in Table II.

1. A booster is generally used with a single pressure circuit when S_{blp} is less than a few inches. This value is necessarily indefinite, since it depends primarily on costs. The cost of valving and the amount of air required to operate the system are two of the major determining factors. However, for extremely high speed operation, a single pressure system should be used.

The booster used may be any of the types shown in Fig. 1. It should be provided with a stroke equal to S_{bhp} plus S_{blp} plus one to two inches of added length for large ram dia, and one to three inches of added length for small ram diameters.

2. A booster such as illustrated at *B* and *C* in Fig. 1 may be used in a dual pressure circuit when S_{blp} is more than a few inches. However, the booster should have a stroke length equal to S_{bhp} plus one to two inches of added stroke for large ram dia, and one to three inches of added stroke for small ram diameters. The oil reservoir should have a volume equal to V_{clp} plus 15 to 40 cu. in. for reserve oil capacity and for air space on top of oil in the tank.

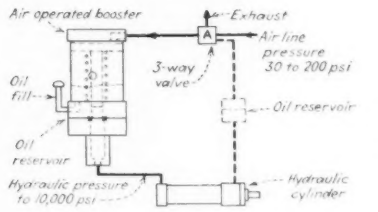
Pistons of cylinders operated by boosters for the working stroke can be returned to the starting position in many ways. Spring return frequently is used for small cylinders with short strokes, such as on portable gun welders or multiple-cylinder spot welders. Cylinder pistons also can be returned by gravity. Sometimes the pistons of hydraulic cylinders are returned by an air cylinder attached externally. A triple seal cylinder has been developed recently that returns the hydraulic cylinder piston with air pressure. Any air leakage past the cylinder seal is bled out to atmosphere through a hole in the piston rod. Thus, no air can enter the hydraulic system no matter how badly worn the cylinder or seals may become. Boosters with small booster ratios frequently are used for returning the hydraulic cylinder piston in a manner similar to the operation of a booster in producing the working stroke. When a working stroke in both directions is required by the cylinder, two high pressure boosters can be used.

Example of Booster Selection

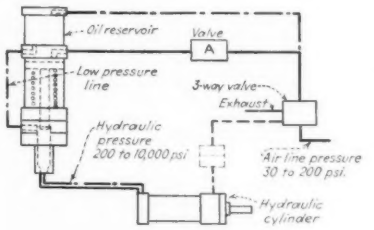
PROBLEM: Punch a $\frac{1}{2}$ in. hole in 16 gauge steel.

The thrust required is approximately 6,000 lbs. This high pressure force

Table II—Booster Circuits—

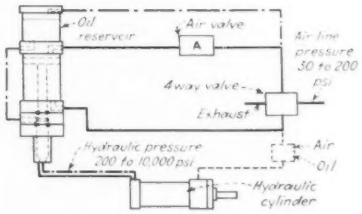


Air to hydraulic booster in a single pressure circuit. This is a single acting spring return unit such as shown at *A* in Fig 1. Air flows through valve *A* to the booster cylinder where it operates the hydraulic ram and is exhausted to the atmosphere on the return stroke. The resulting high pressure fluid actuates the work cylinder. This is the simplest type of booster circuit.



Air to hydraulic booster in a single pressure circuit. The booster is a single acting spring return unit such as shown at *B* in Fig. 1. This system operates in the same way as the circuit shown above. As in all of these circuits the return stroke of the work cylinder can be accomplished either by use of weight, a spring, air, or another booster. If air is used, a four-way valve is required at *A*, and additional piping and an oil reservoir must be added, as shown by the dotted lines.

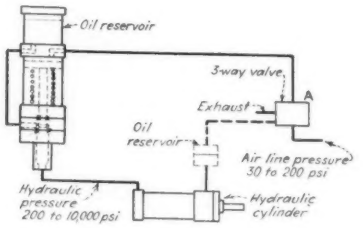
This circuit is more refined than the system shown above and can be jostled more without losing oil.



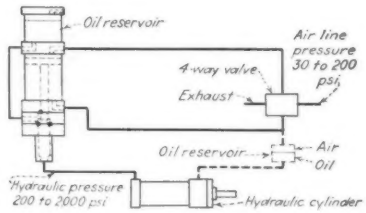
Air to hydraulic booster in a single pressure circuit. This is a double acting booster whose return stroke is accomplished with air. If an air return work cylinder is used, the return air circuit is connected to the four way valve as indicated by the dotted line. In all cases, the oil reservoir in the return air line can be left out if a triple seal work cylinder is used.

This circuit uses more air than either of the two shown above, but is more positive and does not lose power in compressing the spring. Also, this booster is smaller than a spring return unit.

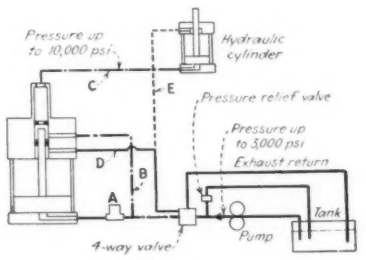
Operations and Limitations



Air to hydraulic booster in a dual pressure circuit. This is a spring return unit. Air flows first to the top of the booster tank, and forces the oil through the low pressure line, through the booster ram cylinder, and into the work cylinder, where it operate the low pressure approach stroke of the work cylinder. As soon as the cylinder meets resistance, the air valve *A* is opened and air causes the booster piston to advance. When the booster ram moves forward, it cuts off the low pressure oil and forces the fluid into the work cylinder at high pressure, thus operating the high-pressure stroke of the work cylinder.



Air to hydraulic booster in a dual pressure system. This is a double acting booster. The text should be consulted to determine when to use dual pressure circuits such as this and that shown above. One of the advantages of these systems is that they save air; they make the most economical use of air of any system yet shown. Other advantages are that a smaller booster can be used than in a single pressure system and that the booster can be applied to a larger system than otherwise would be practical.



Oil to oil booster in a dual pressure system. (Practically all hydraulic to hydraulic units are used in dual pressure systems.) The piping up through the four-way valve represents a more or less conventional hydraulic system. When in operation, oil flows through line *B*, through the booster ram cylinder, through line *C*, and into the work cylinder to operate the approach stroke. When the cylinder encounters resistance, valve *A* is opened and the low pressure oil acts on the booster piston. As the booster ram moves forward, it cuts off the low pressure oil and forces the fluid into the work cylinder at high pressure. The dotted line *E* is omitted if the work cylinder piston is returned by weight or a spring or other means.

must move a minimum of $\frac{1}{8}$ inch. Assume that a 1 in. die opening is required for loading. Then, the approach stroke required equals $1\frac{5}{8}$ inch.

Tentatively assume 1,000 psi hydraulic pressure.

F = Piston area $\times P_h$

6,000 = Piston area $\times$ 1,000

$$\text{Piston area} = \frac{6{,}000}{1{,}000} = 6 \text{ sq in.}$$

A $2\frac{1}{2}$ in. dia. cylinder has an area of 4.9 sq in. and a $3\frac{1}{4}$ in. dia cylinder has an area of 8.3 sq inch. Using a $2\frac{1}{2}$ in. cylinder bore,

$$P_h = \frac{F}{\text{Piston Area}} = \frac{6{,}000}{4.9} = 1{,}225 \text{ psi}$$

$V_c = 4.9 \times 1 = 4.9$ cu in. volume required for total stroke of cylinder.

$V_{chp} = 4.9 \times \frac{1}{8} = 0.306$ cu in. volume required for high pressure stroke of cylinder.

$V_{clp} = 4.9 \times \frac{1}{8} = 4.6$ cu in. volume required for approach stroke of cylinder.

Assume an effective working air line pressure of 80 psi

$$\text{Booster Ratio} = \frac{P_h}{P_a} = \frac{1{,}225}{80} = 15.4$$

Looking in the booster selector chart on line 5, a booster ratio of 16 is developed by a 4 in. air cylinder driving a 10 in. dia hydraulic ram and delivers 0.785 cu in. per in. of stroke.

We now want to determine the booster size and stroke required. Substituting in Eqs 5 and 6,

$$S_{hhp} = \frac{0.306}{0.785} = 1/2 \text{ in. high pressure working stroke.}$$

$$S_{hlp} = \frac{4.6}{0.785} = 5\ 7/8 \text{ in. approach stroke.}$$

Stroke length recommended is

S_{hhp} + (1 in. to 3 in.) = 1/2 + (1 in. to 3 in.) = 2 in.

Either a single acting, spring return or double acting booster can be selected. If a double acting booster is used the booster and cylinder specifications would read:

1. Booster for 80 psi air to 1,280 psi oil, double acting, 4 in. air cylinder bore driving a 1 in. hydraulic ram, 2 in. stroke. Reservoir capacity required would equal approximately 25 cu in. (Specify mounting).

2. A 1,300 psi minimum working pressure hydraulic cylinder (specify mounting), double acting, $2\frac{1}{2}$ in. bore by 10 in. stroke, non-cushioned. (Specify piston rod end style).

A booster with single pressure circuit could easily be applied in this case since the booster size would not be much larger than the one selected above. Since one valve would be eliminated, the first cost would be lower. However, more air would be required to operate this circuit than if a dual pressure circuit were specified.

The booster stroke required for a single pressure circuit would be S_{hhp} + S_{hlp} + (1 in. to 3 in.) = $\frac{1}{2}$ + $5\frac{7}{8}$ + (1 to 3 in.) = 9 in. stroke. Since this stroke is rather long, a spring return booster would not ordinarily be used. Therefore, a double acting booster with normal oil tank reserve capacity would be applied. Specifications would be similar to above except that 9 in. stroke would be called for instead of 2 in. stroke.

If the user had a preference for spring return boosters, one with a larger ram dia and shorter stroke could be selected as follows. Since the use of a dual pressure circuit need not be checked the booster required to operate the total stroke of the cylinder only would be determined:

$$S_h = \frac{V_c}{V_h} = \frac{4.9}{V_h}$$

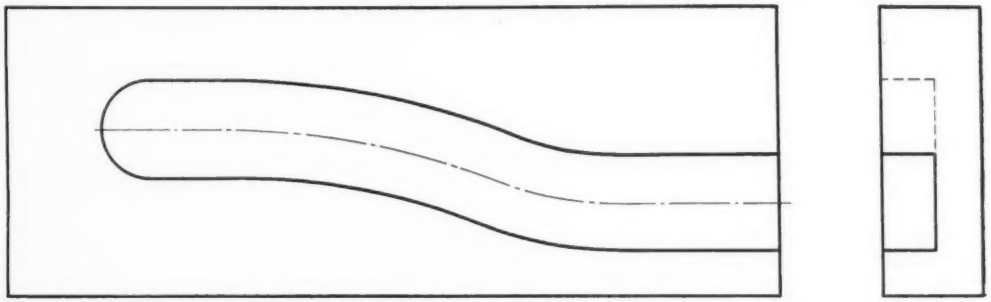
The booster selector chart shows that a booster ratio of 19 is developed by a 6 in. air cylinder driving a $1\frac{3}{8}$ in. hydraulic ram (line 17,) and delivers 1.485 cu in. per in. of stroke. This will give more pressure than required, but air pressure can be reduced to give proper output hydraulic pressure:

$$S_h = \frac{4.9}{1.485} = 3.3 \text{ in. of total theoretical booster stroke required}$$

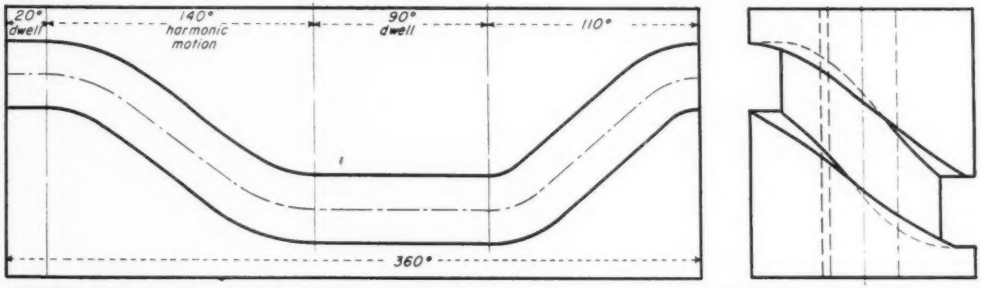
Use 3.3 + (1 to 2 in.) = 5 in. stroke.

If a booster as shown at *A* in Fig. 1 is desired, order as follows: Booster for 67 psi air to 1280 psi oil; single acting, spring return; 6 in. air cylinder bore driving a $1\frac{3}{8}$ in. hydraulic ram; 5 in. stroke. Specify mounting. Since the tank is built in on this model no extra tank is required.

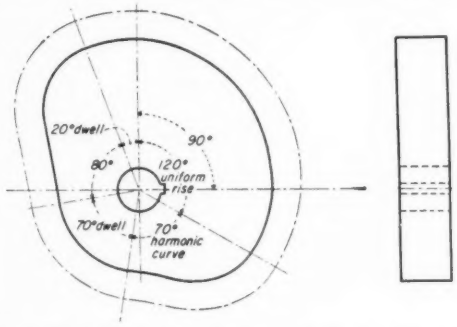
Modifications and Uses for



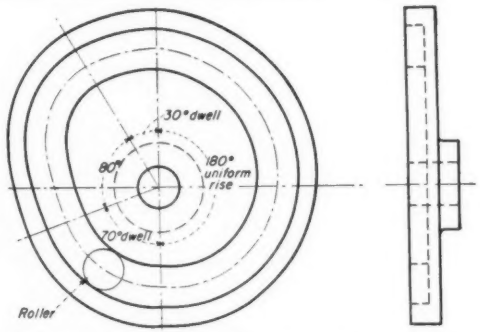
FLAT PLATE CAM—Essentially a displacement cam. With it, movement can be made from one point to another along any desired profile. Often used in place of taper attachments on lathes for form turning. Some have been built in sections up to 15 ft. long for turning the outside profile on gun barrels. Such cams can be made either on milling machines or profiling machines.



BARREL CAM—Sometimes called a cylindrical cam. The follower moves in a direction parallel to the cam axis and lever movement is reciprocating. As with other types of cam, the base curve can be varied to give any desired movement. Internal as well as external barrel cams are practical. A limitation: internal cams less than 11 in. in diam. are difficult to make on cam millers.



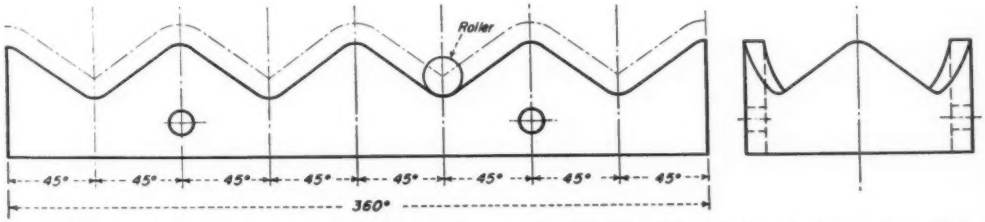
NON-UNIFORM FACE CAM—Sometimes called a disk cam. Follower can be either a roller, hexagon or pointed bar. Profile can be derived from a straight line, modified straight line, harmonic, parabolic or non-uniform base curve. Generally, the shock imposed by a cam designed on a straight line base curve is undesirable. Follower usually is weight loaded, although spring, hydraulic or pneumatic loading is satisfactory.



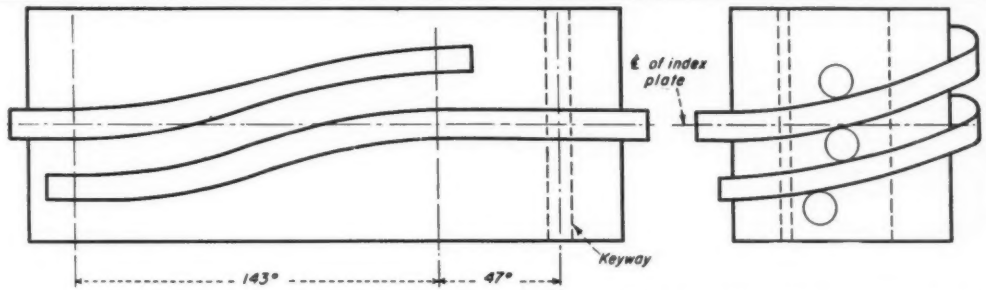
BOX CAM—Gives positive movement in two directions. A profile can be based on any desired base curve, as with face cams, but a cam miller is needed to cut it; whereas with face cams, a band saw and disk grinder could conceivably be used. No spring, pneumatic or hydraulic loading is needed for the followers. This type cam requires more material than for a face cam, but is no more expensive to mill.

Basic Types of Cams

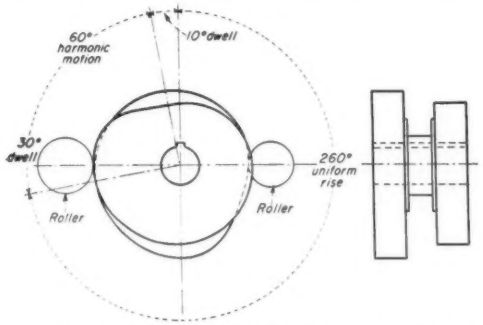
EDWARD RAHN
Chief Engineer, Rowbottom Machine Co. Inc.



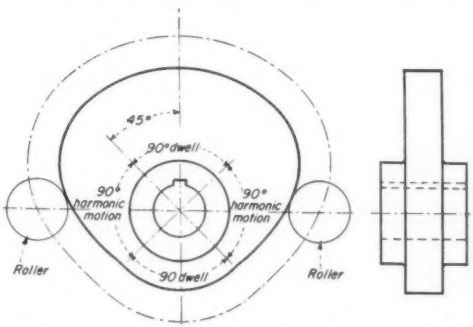
SIDE CAM—Essentially a barrel cam having only one side. Can be designed for any type of motion, depending on requirements and speed of operation. Spring or weight loaded followers of either the pointed or roller type can be used. Either vertical or horizontal mounting is permissible. Cutting of the profile is usually done on a shaper or a cam miller equipped with a small diameter cutter, although large cams 24 in. in diameter are made with 7-in. cutters.



INDEX CAM—Within limits, such cams can be designed for any desired acceleration, deceleration and dwell period. A relatively short period for acceleration can be alloted on high speed cams such as those used on zipper-making equipment on which indexing occurs 1,200 to 1,500 times per minute. Cams of this sort can also be designed with four or more index stations.



DOUBLE FACE CAM—Similar to single face cam except that it provides positive straight line movement in two directions. The supporting fork for the rollers can be mounted separately or between the faces. If the fork fulcrum is extended beyond the pivot point, the cam can be used for oscillatory movement. With this cam, the return stroke on a machine can be run faster than the feed stroke. Cost is more than that for a box cam



SINGLE-FACE CAM WITH TWO FOLLOWERS—Similar in action to a box or double face cam except flexibility is less than that for the latter type. Cam action for feed and return motions must be the same to prevent looseness of cam action. Used in place of box cams or double face cams to conserve space, and instead of single face cams to provide more positive movement for the roller followers.

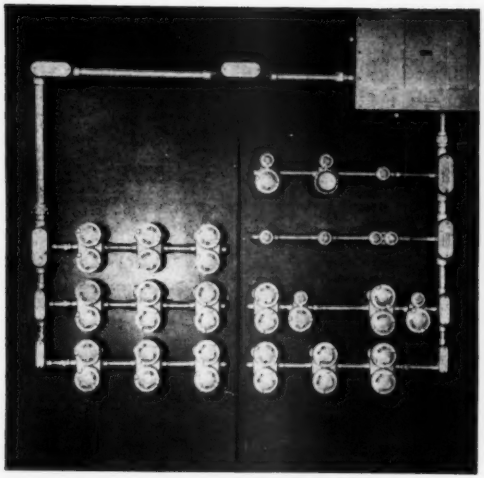


Fig. 1—Rear view of control panel with Underwriters Class II location inclosures for protection against combustible dusts.

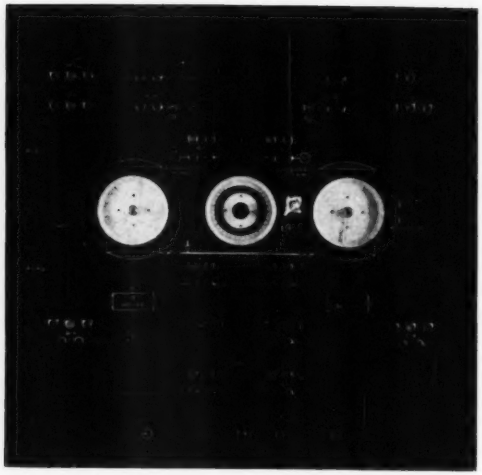


Fig. 2—Unit package assembly includes miscellaneous equipment and two cam type units using hermetically sealed contacts.

Industrial Time Controls—III

Preparation of Specifications

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ENGINEERS should consider and summarize many details concerning the requirements of a prospective installation of time controls when planning a control system for an automatic machine or process. A general discussion of the scope and diversity of this specialized field of engineering has been presented in previous articles. Part I, PRODUCT ENGINEERING, February, 1949, p. 125, outlined suggested standards for nomenclature and diagramming of industrial time control devices. Part II, PRODUCT ENGINEERING, March, 1949, p. 119, discussed a number of constructions and set forth the principal advantages and limitations of each.

In general, the discussion presented here will deal with factors that should be studied by design engineers when originally arranging machines or process layouts. A well planned project will facilitate assembly and subsequent inclusion of time control equipment. In addition, much information will be collated that is needed by a time control manufacturer in making a quotation. Frequently the timer control engineer can make valuable suggestions concerning the machine or process design if he is consulted in the preliminary development work.

In the preparation of time control specifications, the prospective purchaser or application engineer should describe fully the conditions existing at the point of installation. These data are desirable because manual machine functions, and associated apparatus such as electric motor controls, limit switches, and instruments, all have a direct bearing upon the final design of the time control.

First, a general description of the machine or process to which the time control is to be applied should be written with a brief outline of those functions that the time control will actuate. Available blueprints, printed sales and engineering literature covering the general process or machine should be part of the specifications. A detailed outline should then be made of the sequence of the automatic operations with time limits, maximum and minimum, for each of the adjustable time periods with a statement as to the mode and degree of adjustability required on each time period. This information can best be presented as shown in Fig. 3, that is, in time-chart form.

A description should be given of the pneumatic or electrical devices that the time control will actuate, with all their ratings and the rating of the source of power for the time control equipment. In an electric system, the description should include voltage, horsepower, current, frequency, and number of phases; and for pneumatic systems, the pressure, piping sizes, and cubic feet per minute required by the various devices. If there are preferences in the type of contacts that are to be employed, these should be expressed. For an existing control system, wiring or piping diagrams of the system components should be supplied.

Mention should be made of the conditions existing at the place of final installation such as ambient temperature ranges, hazardous conditions (dusts, explosives), normal weather conditions if outdoors; and the amount of mechanical wear expected on the inclosures, such as shock, and vibration. If known, the Underwriters' classification of the location, or the NEMA type of inclosure required should be stated. Fig. 1 is a rear view of a time control panel with Underwriters Class II location inclosures for protection against combustible dusts.

Preference should be expressed as to how the time control is to be started and, if applicable, the nature of exist-

ing starting equipment or devices. This information is important to the time control engineer in planning for reset or non-reset action, stop-cycle or repeat-cycle operation, and other optional functions. If industrial measuring instruments are to initiate the time control's program, the duration and frequency of closure, and current rating of the instruments' contacts as well as the number of poles, throws, and normal positions are necessary data.

The desired action of the time control in the event of deliberate or accidental power failure and the subsequent return to normalcy should be specified; some machines and processes demand that the time control reset immediately to its start of program position. This condition means that the cycle will start from the normal starting position when power is again restored. Other systems require that the time control remain in place at the time of line power interruption and continue the program from that point upon resumption of power.

Again, some automatic machines and processes remain dormant after power is restored until a push button or other starting contact is made; whereas others proceed immediately without any deliberate starting action. These alternates must be considered and selected by the machine designer based on his knowledge of the process. When stipulated in the specifications, these data can guide the timing device manufacturer in making his recommendation.

It is recommended that a statement be made as to whether it is desirable, mandatory, or unnecessary that there be some visual indication of the progress of the cycle of operations, and the preferred form of this indication such as dial, pointer, disk, or lights. Frequently, the operational usefulness of the time control can be extended when such preferences are incorporated in the original requirements.

The life expectancy of the time control equipment should be expressed, preferably in the number of operations per unit of time and in the total number of units of time. Normally, this number would be the same as that of the automatic machine or process equipment upon which the control is installed, although periods of manual operation may reduce the expected life of the time control equipment below that of the machine or process. The life expectancy of the time control is helpful to the manufacturer when recommending time control equipment of reasonable and proportional quality and ruggedness as compared with the machine or process controlled.

In their inquiry specifications, prospective users are advised to include a statement as to which of the following three general methods of supplying the time control equipment is preferred, or if the recommendation of the time control manufacturer would be entertained. The first method would call for unmounted units to be supplied by the time control manufacturer, later to be mounted in the customer's inclosures or machines. Because of the absence of cases and housings, this is the least expensive way of purchasing time control equipment. When remounted in the customer's machine or inclosures, the final job is usually more satisfactory from a finished design standpoint. The job of tying in the time control equipment with auxiliary equipment to be controlled, however, must then be done at the time of assembly of the machine or process, not in the plant of the time control manufacturer. Responsibility for the proper inter-connections and functioning of the time control equipment must then be carried by the machine assembler. If this arrangement is selected, the available space and method of mounting should be specified and whether the unit must include its own internal wiring or not.

A second method calls for the purchase of standard single-purpose inclosed time control units that are to be applied in accordance with standard instructions on the scene of the installation. This category probably includes the overwhelming majority of purchased time control units. Most manufacturers list operating specifications in their catalogs, usually they are the most economical solutions to any time control problem that can be solved by the application of one time control unit of standard manufacture. If this method is used, the type of case preferred should be specified such as surface or flush, standard or dust-tight, weather-proof or explosion-proof. When timing problems become more complicated, this method of supplying the timing equipment becomes increasingly unsatisfactory and costly; for the reason that units must be built up into combinations, physically and functionally. Also, since the inclosures and equipment are originally made to fulfill a single purpose, the design of the final installation can leave much to be desired in appearance, function, and cost.

Finally, there is the "Unit Package" method of having the time control manufacturer supply a time control panel assembly that includes all the timing equipment and a logical portion of the auxiliary equipment all interwired and mounted in a single inclosure, ready for quick installation on the scene of the application. This method of supplying timing equipment is of particular advantage when the timing functions are numerous and complex, and where the time control manufacturer can reasonably supply whatever auxiliary equipment is needed.

Engineers of the timing equipment manufacturer after studying the customer's requirements usually recommend and design the complete unit package. This procedure is more advantageous than a miscellaneous field assembled layout, because then the time control manufacturer is responsible for the complete functional success of the timing system, and also because the equipment is practically ready for operation at the time it reaches the scene of installation. If this arrangement is preferred, the available space, the conditions of environment, and proposed methods of mounting and installation should be specified. The unit package time control shown in Fig. 2 includes in one assembly two cam type units with hermetically sealed contacts plus various control and terminal equipment.

Any additional information that may be of assistance in solving the particular time control problem should naturally be included in the specifications. Frequently, quantities needed, delivery schedules that must be met, and price limitations will be of critical value to the time control engineer.

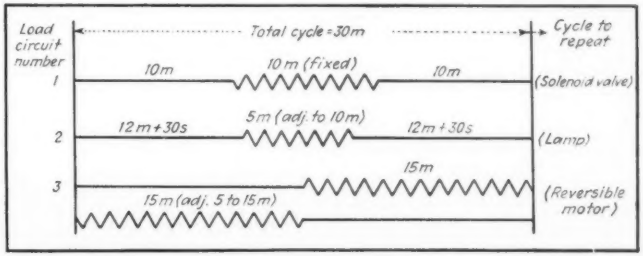

Fig. 3—Example of a timing chart that should be included in inquiry specifications.

Limit Switch Circuits for Electric Motor Drives

Methods of controlling the displacement and reversal of machines equipped with either reversing or non-reversing electric-motor drives. Circuit operation and application.

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Electrical Engineer
Reed-Prentice Corporation

LIMIT SWITCHES are included in the motor control circuits of industrial equipment to keep the travel of the operating members within safe limits, to stop machine motion at preselected points, or to automatically stop and reverse the direction of travel. For example, "over-travel" limit switches are used on cranes to prevent hoists from running off the cross rail, and on machine tools, to prevent the machine table from running off the ways: "Position" limit switches often are added to metal working machines such as automatic lathes (to control depth of feed), screw machines (to control cycle action), and drill presses (to control downward travel of spindles). "Reciprocating" limit switches are applied to grinders, planers, plastic injection presses or any machine having an automatic reversal at the end of the working or return stroke. It is proposed here to analyze some of the conditions that govern the relationship between the machine motor, its control, and the driven member, and hence the type of limit-switch circuit that is to be chosen.

TYPES OF MOTOR DRIVES

The manner in which a limit switch is wired in a control circuit depends on whether the drive is of the reversing or non-reversing type. Individual power units, consisting of alternating-current induction motors or direct-current shunt-wound motors, are the usual source of energy for machine feed drives. The transmission of the power from the motor shaft to the machine member is accomplished through mechanical or hydraulic means, while the control of the machine may be mechanical, electrical, electronic or hydraulic —or any combination thereof.

Clearly, a reversing linear motion does not necessarily imply a reversing electric motor. This fact immediately brings about a distinction of drives into two general categories, namely reversing drives with non-reversing motors and with reversing motors. Examples of reversing drives with non-reversing motors are systems that:

1. Consist of an electric motor coupled to a hydraulic pump. The pump supplies power to a hydraulic motor, which in turn drives the machine member. Mechanically or electrically controlled valves are usually employed to reverse the hydraulic motor and thus the drive. Systems of this type are common on machine tools.

2. Consist of forward and reverse gear trains, which are connected to the driven member through gear shifting clutches. Systems of this type are often used on machine feed drives.

3. Consist of an electric motor coupled to a hydraulic pump, which drives the machine members through reciprocating hydraulic cylinders. Reversal of motion is accomplished by electrically or mechanically operated hydraulic valves. Plastic molding presses, sheet metal presses, and die casting machines usually have hydraulic drives. Combined hydraulic-pneumatic drives are similar in operation.

To the second category—drives with reversing motors—belong those where the driven element is geared directly to the motor. Obviously in order to reverse the drive, it is necessary to reverse the motor. Spindle and feed drives on machine tools equipped with a lead screw fall in this group.

REVERSING DRIVES WITH NON-REVERSING MOTORS

In Table I are shown limit switch circuits representative of those suitable for reversing drives with non-reversing motors. These diagrams show the limit switches wired in low voltage a-c control circuits in the conventional manner. The same control circuit may be applied on either a 3 phase a-c or a d-c power supply for the motor. For that reason, the diagrams for both an a-c squirrel cage motor and a d-c shunt-wound motor are shown at the top of the table; the behavior of both types is identical in respect to the principles under discussion. Of course, only one motor at a time is used on a drive.

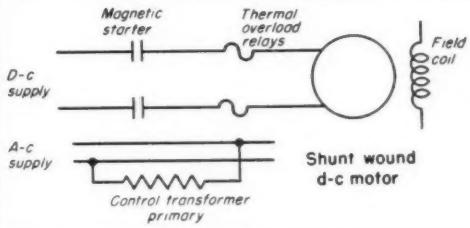
Diagram *A* is the simplest form, with the limit switches forward, *LS-F*, and reverse, *LS-R*, wired in series with coil *M* of the magnetic motor starter. When a part of the machine resets on either of the two limit switches, the motor is stopped. Power reversing is impossible without first backing-up the machine by hand cranking just enough to reset the limit switches. Such a scheme is, of course, acceptable only on small machines or whenever hand-cranking is not likely to be a frequent occurrence. Moreover, only emergency or overtravel limit switches are suitable for wiring in this way.

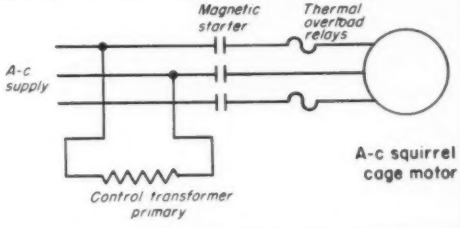
Power reversing may be brought about by a scheme that by-passes the open contacts of the switch once it has tripped. The auxiliary devices and wiring required for this purpose are shown in *B* and *C*. Scheme *C* entails the addition of two auxiliary relays *F* and *R*, energized by a set of sustained contacts (cam operated limit switches, selector switches, or drum switches) which may in turn be operated by the machine control levers. This is equivalent to make the forward limit switch inoperative throughout the reverse motion, and vice-versa. Electrical interlocking between *F* and *R* is a measure of precaution. Both circuits are suitable for overtravel protection and position, ing, and with some modifications, for reciprocation.

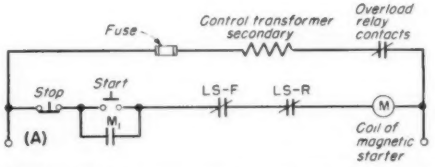
A typical condition encountered in hydraulic drives where directional control is accomplished by solenoid operated valves is represented by circuit *D*. This diagram implies the presence of spring-centered valves and sustained operation of the directional push buttons; when both valves are de-energized, the drive is in neutral.

When sustained push buttons are not acceptable, or when automatic control is desired and the task of stopping the drive at predetermined positions is to be performed solely by limit switches, momentary push buttons are used, wired in parallel with a set of holding contacts provided by two auxiliary relays *F* and *R*. Such a condition is represented in diagram *E*. Circuits *D* and *E* may also be applied to mechanical, instead of hydraulic drives, that

Table I—Limit Switch Circuits for Reversing Drives with Non-Reversing Motors

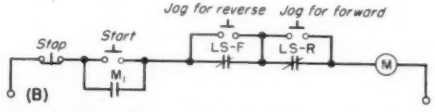






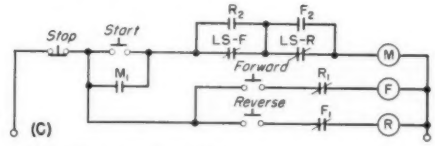
OPERATION: When start button is pressed, coil *M* of magnetic starter is energized: contacts of starter close and motor is connected to power supply. Holding-contact M_1 keeps coil of starter energized after button is released. Tripping of forward or reverse limit switches *LS-F* or *LS-R* de-energizes coil *M:* motor is disconnected.

APPLICATION: As overtravel or emergency safety circuit. To restart motor after limit switches have tripped, machine must first be manually backed off the limit switch.



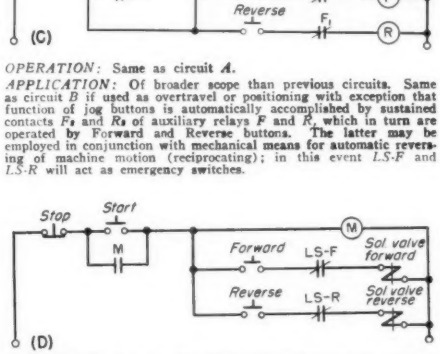
OPERATION: Same as circuit *A*.

APPLICATION: As overtravel or positioning circuit. Jogging buttons make it unnecessary to back off machine manually when a switch is tripped.



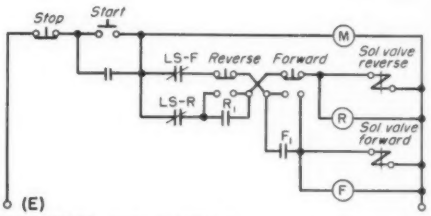
OPERATION: Same as circuit *A*.

APPLICATION: Of broader scope than previous circuits. Same as circuit *B* if used as overtravel or positioning with exception that function of jog buttons is automatically accomplished by sustained contacts F_2 and R_2 of auxiliary relays *F* and *R*, which in turn are operated by Forward and Reverse buttons. The latter may be employed in conjunction with mechanical means for automatic reversing of machine motion (reciprocating); in this event *LS-F* and *LS-R* will act as emergency switches.



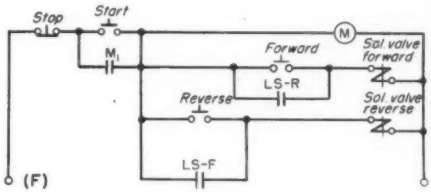
OPERATION: Same as Circuit *A*, except that tripping of limit switches *LS-F* and *LS-R* does not stop the motor.

APPLICATION: On hydraulic drives as positioning or overtravel circuit. Valves are spring centered. Forward and reverse buttons are of the sustained type. Tripping of limit switches de-energizes the solenoid valves and thus stops the machine motion.



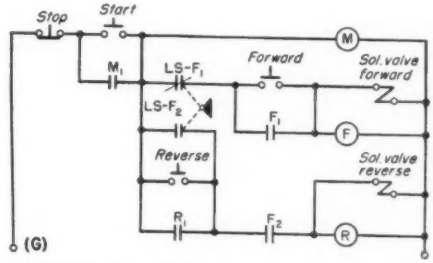
OPERATION: Same as circuit *D*.

APPLICATION: Same as circuit *D* except that forward and reverse pushbuttons are momentary. Solenoid valves are kept energized by holding contacts F_1 and R_1 of auxiliary relays *F* and *R*. Interlocking of normally closed contacts of forward and reverse push buttons prevents simultaneous energization of both valves.



OPERATION: Same as circuit *D*.

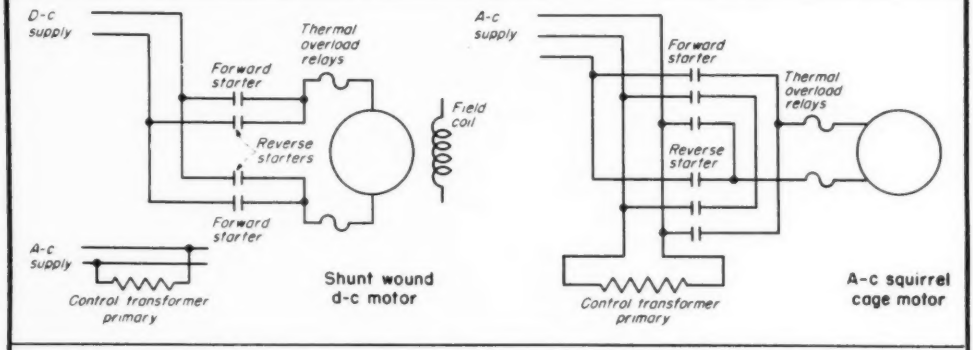
APPLICATION: In reciprocating motions when valves are of centerless type, pushbuttons of momentary type. At the end of forward stroke, limit switch *LS-F* energizes reverse valve, starting reverse stroke; at end of reverse stroke limit switch *LS-R* energizes forward valve starting forward stroke. No intermediate position obtainable with simple electrical means.

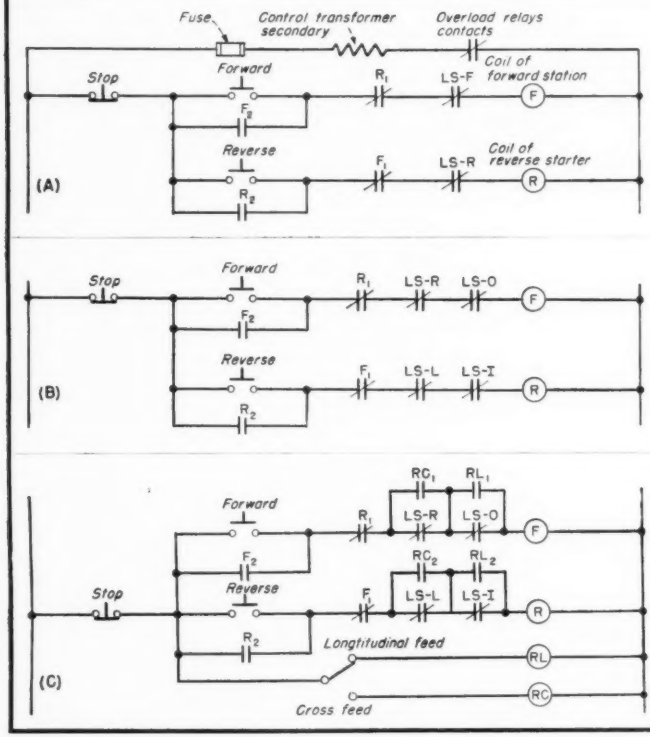


OPERATION: Same as circuit *D*.

APPLICATION: Limit switch *LS-F* acts as reciprocating device in a drive where valves are spring-centered and pushbuttons momentary. Forward motion is started by respective pushbuttons. At end of stroke $LS\text{-}F_1$ opens and $LS\text{-}F_2$ closes; forward solenoid is de-energized, reverse solenoid is energized; reverse motion is started. Reverse solenoid is kept energized by holding contact R_1 of relay *R*. Interlocking contact F_2 prevents simultaneous energizing of forward and reverse solenoids.

Table II—Limit Switch Circuits for Reversing Drives with Reversing Motors





OPERATION: When forward pushbutton is pressed, coil F of magnetic starter is energized through interlocking contact R_1 and limit switch $LS\text{-}F$. Contact of starter F closes and motor is connected to power supply in forward direction. Holding contact F_2 keeps coil F energized after pushbutton is released. Same sequence occurs for reverse circuit. Tripping of $LS\text{-}F$ or $LS\text{-}R$ de-energizes coils F or R and disconnects motor.

APPLICATION: On general purpose reversing drives, as overtravel, position or reciprocating basic circuit.

OPERATION AND APPLICATION: Similar to circuit A. However, this circuit symbolizes drives where two machine motions are provided for each direction of motor rotation. When motor is running forward, tripping of either $LS\text{-}R$ (Right) or $LS\text{-}O$ (Out) will stop it; when $LS\text{-}R$ has tripped, no further motion in "out" direction is possible; when $LS\text{-}O$ has tripped, no further motion in "right" direction is possible.

OPERATION AND APPLICATION: Symbolizes dual motion drives same as B. However, to overcome the range limitation of circuit B, a selector switch for longitudinal or cross feed is added, with two auxiliary relays RL and RC. When the motor is running in reverse (R energized) and the machine is moving in a longitudinal direction towards the left (RL energized) contact RL_2 by-passes limit switch $LS\text{-}I$ (In) in path of cross-feed motion. Only tripping of $LS\text{-}L$ (left) will de-energize R and stop motor. So, in a given motion, only the two limit switches that are in the path of that motion are effective.

employ solenoid-shifted clutches for directional control.

When centerless, or "latched-in", valves are used instead of the self-centering type just mentioned, no neutral position is available, and feed control cannot be accomplished by limit switches. This is due to the fact that once the operating solenoid has been energized and the spool of the valve has shifted, the absence of the spring prevents the valve from resetting even after the solenoid becomes de-energized. However, reciprocating limit switches may be used for automatic reversing of the drive, as indicated in diagram F.

Circuit G is suitable for automatic reversal of a hydraulic drive that is equipped with self-centered solenoid valves. Both the normally open and normally closed contacts of reciprocating limit switch $LS\text{-}F$ are used, and two auxiliary relays F and R are required. Schemes F and G have found wide acceptance in such circuits as those for automatically controlling plastics injection molding and die casting machines.

In the drives represented by diagrams A, B and C, action of the limit switches is such that the motor is stopped when the switch is tripped;

the motor may be restarted only after the mechanical operating means have engaged the drive in reverse, and the open contacts of the switch are reset or shunted across. Instead, in circuits *D*, *E*, *F* and *G* the motor is not affected, because the limit switches are in series with the solenoids that control the driven member and are independent of the motor starter *M*. Consequently, the motor is running regardless of whether the drive is feeding or is in the neutral position, or the machine is at rest on a limit switch; it is stopped only through the action of the "Stop" push button.

Drives with Reversing Motors

Different circuit arrangements are necessary if the limit switches are to be used in conjunction with a reversing electric motor, and especially if the motor is to drive more than one machine mechanism. Three common methods of applying reciprocating limit switches to such drives are shown in Table II.

In circuit *A*, forward limit switch *LS-F* is in series with forward contactor *F* and normally-closed interlocking contact *R*. When the drive is moving forward, tripping of *LS-F* de-energizes *F* which stops the forward motion and releases the interlocking contact. The circuit of contactor *R* can then be energized. Thus, when the drive is at rest on a switch, it can be reversed by power. This circuit is commonly used for reciprocating drives, and for plugging or dynamic braking circuits.

There are many applications in which the motor is the source of power for more than one feed motion. Fig. 1 represents graphically the limits of

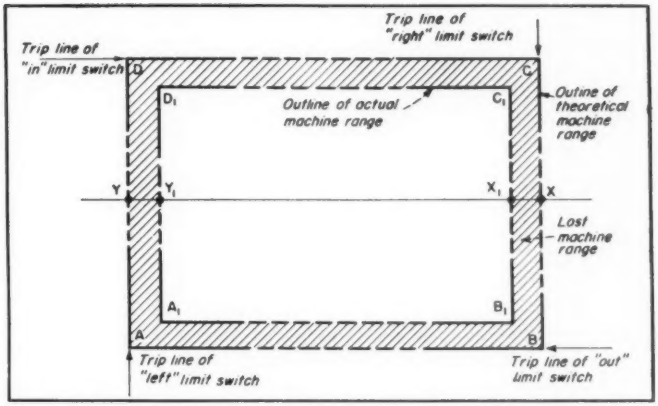


Fig. 1—When limit switches are used on dual motion drives, the theoretical machine range is decreased by the distance between the disconnect and reset points of each limit switch, usually referred to as the switch differential.

dual motion feed drive, involving longitudinal (left-right) and crosswise (in-out) displacements. Two sets of limit switches are used; this is the condition, for instance, of the table of certain milling machines. It is assumed that the motor is reversing, and running clockwise when the machine is feeding in the "Right" or "Out" direction. Limit switches *LS-R* (right), and *LS-O* (out) are wired in series with coil *F* (forward), while *LS-L* (left) and *LS-I* (in) are wired in series with coil *R* (reverse), as shown in Table II, circuit B.

Suppose that the table, traveling along line *YX* in Fig. 1 reaches the extreme position *X* and is stopped by action of "right" limit switch *LS-R* (circuit *B*). Relay *F* is then de-energized. If the machine operating lever is now being shifted to the "out" position for a motion from *X* towards *B* nothing has occurred to release the open contacts of *LS-R*, and relay *F* cannot start the drive; consequently, the "out" motion is blocked. To energize *F* it is first necessary to back up from *X* to a position X_1 very close to *X*, but still far enough for the contacts of *LS-R* to permit resetting. The motion then will be along line $X_1 B_1$ rather than along *XB*. Analogous considerations apply for the "left" and "in" motions and their respective limit switches.

Hence, under certain conditions the shaded area in Fig. 1 is not available

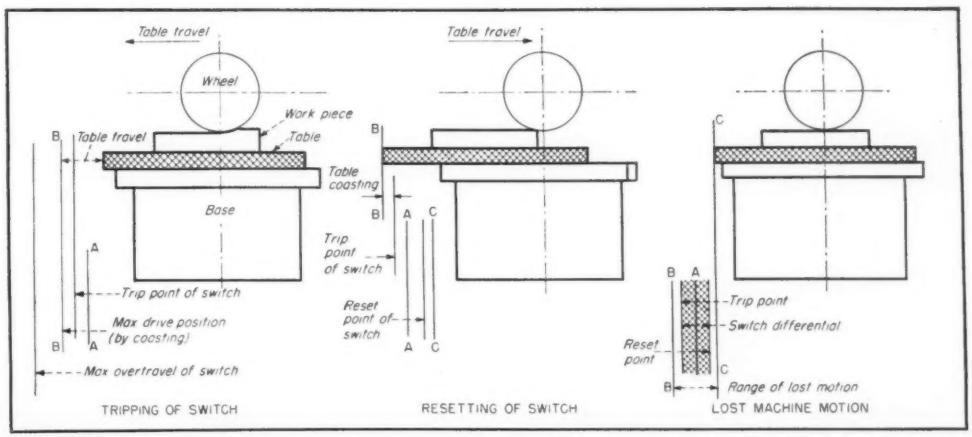


Fig. 2—Sequence of drive action that results in "dead-centering" of drive and consequent loss of range unless the limit switches not in the path of motion are shunted out of the circuit.

for power feed. Analysis of circuit *B* indicates that when the table resets on point *X*, motion *XC* (an "in" motion) is open to power feed because in this case relay *R* becomes energized, and nothing occurs to disturb this status until the extreme point *C* is reached, where limit switch *LS-I* (In) is tripped and its normally closed contacts are open; through this action relay *R* becomes de-energized. At this time relay *F* is still de-energized. Clearly then, no further feed motion is possible in any direction unless the table is first cranked back enough to release either or both *LS-R* and *LS-I*, making it possible for *R* or *F* to be energized. The conditions are that the sequence of motions be such than when an extreme "right" position is reached, the next motion be "out"; when an extreme "out" position is reached, the next motion be "right"; when an extreme "left" position is reached, the next motion be "in"; and when an extreme "in" position is reached the next motion be "left".

A geometrical explanation and a clue to the size of the lost area of Fig. 1 may be found in the analysis of Fig. 2. The make and break (or reset) points of limit switches is not the same. The differential is variable depending upon type and make of switch: it is usually smaller in snap action than in slow action switches; smaller in precision type than in heavy duty industrial switches; it may be a linear quantity as represented in Fig. 2, or an angular rotation for lever operated switches. But whatever the condition, it is a definite quantity with which the product designer must contend.

Line *B* indicates the machine range and is extremely close to the trip line of the limit switch, the distance between the two being determined by the amount of machine coasting. Line *A* is the position at which the machine member should stop to avoid tripping the limit switch, and differs from the trip line by an infinitesimal quantity. Line *C* is the position at which the machine must stop when backing up just enough to reset the switch, and almost coincides with reset line itself. Consequently, the size of the shaded area of Fig. 1 representing a loss in machine range is, for practical purposes, controlled by the differential points of the limit switch.

The condition illustrated above, involving back-up before motion shift and a reduction of machine range, may sometimes be a handicap. Such a handicap can be overcome if a scheme is adopted, whereby during each motion, the limit switches that are not in the path of the motion are shunted out. This scheme is illustrated in circuit *C*, Table 2. In the previous circuit the selection of feed and direction thereof must be accomplished through mechanical means, such as lever-shifted clutches. In this circuit, levers can be so designed that they operate a limit switch with a set of normally open sustained contacts; these, in turn, energize two auxiliary relays, namely *RL* for longitudinal feed, and *RC* for cross-feed. When *RL* is energized during longitudinal feed, limit switches *LS-I* and *LS-O* of the cross-drive are shunted out and are thus inoperative. Likewise, when the cross-feed is selected, limit switches *LS-R* and *LS-L* of the longitudinal feed are made inoperative through shunts closed by relay *RC*. Thus, the full machine range is available and there is no limitation in the use of the limit switches. In other words, the drive falls in the category illustrated by circuit *A* in Table 2.

It is evident that this procedure may be readily extended to drives involving three, rather than two, motions.

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PREVENTING CREEP in rayon motors is problem because the usually unbalanced load in the rayon buckets is spun at high speed.

Creep of Ball Bearing Races

Causes for the creeping of outer races of ball bearings, and the harmful effects produced. Methods for minimizing or preventing creep are included.

IRVING KALIKOW
Motor Engineer, General Electric Company

CONTRARY to widely-held opinion, slow creep of the outer race of a ball bearing in its housing to equalize its wear is neither necessary nor desirable. Creep is especially damaging when vibration or similar factors are encountered. Recent analysis of the exact cause of creep has given a better understanding of the action and resulted in the development of improved methods for its prevention.

It has been generally believed that some clearance should be left between the bearing and its housing such as shown in the typical assembly of Fig. 1, so that creep could occur. Thus, it was thought that every portion of the outer race would eventually bear the load, and continuous stress on one section of the outer race would be avoided. But experience shows this avoidance of stationary stress is unnecessary. Fatigue failure records of ball bearings with restrained outer race prove that approximately 60 percent are inner race failures, 20 percent are ball failures, and 10 percent each are retainer and outer race breakdowns. The six-to-one difference between inner and outer race failures is caused by the relative areas in contact with the load. The contour of the outer race tends to conform to the shape of the ball, whereas the inner race curves away from the point of contact.

CREEP ALWAYS HARMFUL

Outer race rotation or creep with respect to its housing is never desirable. Eventually it causes wear of both bearing and housing. This not only increases the clearance, but the wear products may find their way into the bearing and hasten failure. Some types of creep, characterized by high unit pressures and minute motion, cause "fretting corrosion." This corrosion material, iron oxide, plus oil or grease is an effective grinding compound. Creep may shorten the life of the bearing, and may increase objectionable noise and vibration. Since housing wear almost always calls for a major repair, creep should be prevented.

Well established practice in design of rotating elements is to use a free or floating fit on one or both bearings. Axial movement for at least one bearing in its housing is necessary for differential expansion between length of shaft and housing. Also, this compensates for the dimensional tolerances

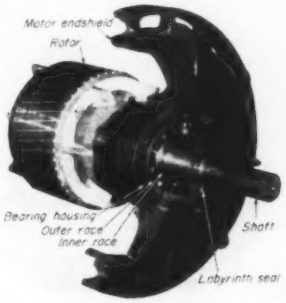


Fig. 1—Typical construction and mounting detail of ball bearing for totally-inclosed fan cooled squirrel-cage motor. For vibration loading, circumferential toroid type spring is placed inside housing.

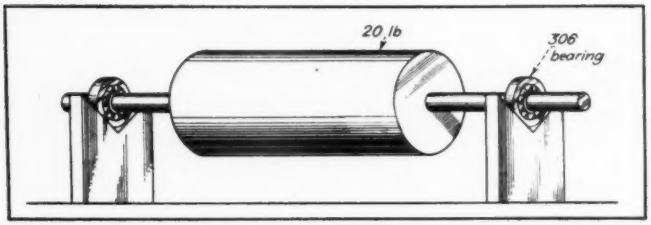


Fig. 2—Regardless of speed of 20 lb rotor, outer races will not turn in V-block supports.

of the component parts. Only rarely are both bearing races positively restrained from axial motion.

With free or floating fits, outer race rotation occurs only if (1) The restraining torque on the outer race is less than the internal torque, or (2) rotating load is applied to the outer race of the bearing that produces enough torque to overcome the restraining torque.

Internal Torque Causes Spin

If a 20 lb rotor with two 306 bearings are supported on V-blocks as shown in Fig. 2, for example, no speed of rotation will cause the outer races to turn in the blocks. The weight of the rotating parts produces more than enough external friction torque on the V-blocks to prevent the internal friction torque from rotating the outer race. Generally, the internally generated friction torque attempting to turn the outer race in the direction of shaft rotation is extremely small in magnitude as compared to the radial loads supported by the bearing.

Calculations can give only approximate values for internal friction torque. Two major factors that can not be evaluated accurately are the effects of lubricant and seals. In addition, the torque is dependent on the bearing dimensions, load, and speed. As a first rough approximation, one bearing manufacturer suggests that where:

M = internal friction torque, mm kg
d = bearing bore, mm
Q = bearing load, kg
mm kg × 0.0866 = in. lb.

then:

$$M = \frac{(d)^{5/3}}{2{,}000} + \frac{(Q\,d)^{2/3}}{500}$$

For a 306 bearing with 160 pounds radial load and operating at 3,600 rpm, this formula gives an input loss of 14.3 watts. Tests show that the loss is about 3 watts for ordinary greases, and as high as 25 watts for extremely viscous greases. The torque corresponding to 25 watts is 0.58 inch pounds and the torque for 3 watts is only 0.07 inch pounds.

Assuming the load in Fig. 2 is evenly divided and the static coefficient of friction is 0.2, then the 306 bearings supporting the 20 lb rotor load would normally produce about 2 lb available friction force on the outer race. Since the bearing has a 2.835 in. OD, the available friction torque is 2.8 inch pounds. This is 40 times the torque necessary to prevent rotation for the average grease, and 5 times the torque generated by an extremely viscous grease.

Therefore, internal bearing friction rarely is the cause of outer race rotation in horizontally supported machines. Exceptions are when the radial load is extremely small for the size of bearing used, or when the grease or seal friction is unusually high. Small radial loads often occur in vertically mounted elements where bearings are essentially line-up devices. For this condition, internal friction may cause rotation of the outer race.

The rotation caused by internal friction is always in the same direction as shaft rotation. Maximum speed of race rotation is limited only by the shaft speed. The outer race is constantly accelerated by the torque difference between the internally generated torque and the externally available torque. Thus the rate of creep can be anything up to the shaft rotation rate. Such a condition is more properly termed "outer race spin" rather than creep.

Rotating Load Causes Creep

True creep is always caused by a rotating load applied through the bearing. Generally it is of extremely slow rate and always in the opposite direction to the load rotation. Factors governing the tendency of a bearing to creep are: (1) The stationary radial load, (2) the rotating load, (3) the clearance between the housing and bearing, and (4) the restraining force. For conditions where sufficient clearance exists, the outer race will act like an internal gear. As shown in Fig. 3 for each complete rotation of the load, the outer race rotates in the opposite direction by a small amount. Where: CR = creep rate, rpm; RL = rotating load, rpm; C = clearance, in.; OD = bearing outside diameter. Then

$$CR = RL\,\frac{C}{OD}$$

Thus, if the clearance were 0.0003 in., a 205 bearing of 2.047 in. diameter with rotating load of 1,800 rpm would have a backward creep of $1{,}800 \times \frac{.0003}{2.047} = 0.27$ rpm.

The load must rotate completely around the circumference of the bearing for creep to take place. Therefore, the rotating force must be greater than any stationary radial load; otherwise the bearing will merely rock, not creep, as shown in Fig. 4. Vectorial addition of the rotating and stationary forces must produce a net force that travels around the housing. A net rotating force less than the stationary force merely moves the load point up and down a portion of the housing.

Stationary radial load on a bearing can be caused by gravity, belt pull, magnetic side pull in electrical machinery, and many other means. When considering the possibility of creep, it is essential to know the magnitude of the stationary load. For instance in electrical applications, the side pull of magnetic forces may reduce the gravity bearing load or that of belt pull, to such a degree that small rotating forces can cause creep.

If the flux distribution around the air gap of an electrical machine is uniform, there is no side pull. But generally, flux distribution is not uniform because of non-uniformity of the gap. Necessary machining tolerances can easily vary the air gap from 0.001 to 0.005 in. Thus side pull usually exists in most rotating electrical machinery. An unbalanced air gap of only 0.001 in. can cause a

Table I—Net Pull per Unit of Unbalanced Gap in Typical Motors

Hp	Rpm	Poles	Net Pull on Rotor, lb. per 0.001 in. unbalanced gap
Polyphase Motors			
¾	900	8	68.3
1½	1,200	6	52.7
2	1,800	4	29.6
3	3,600	2	8.3
7½	900	8	127.0
10	1,200	6	109.0
15	1,800	4	63.5
20	3,600	2	27.2
Single Phase Motors			
½	900	8	48.0
1	1,200	6	45.4
2	1,800	4	35.9
3	3,600	2	9.4

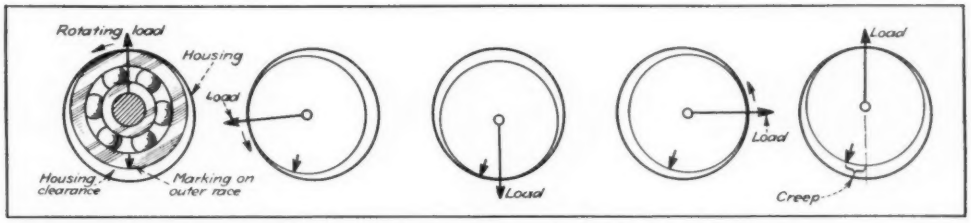


Fig. 3—For each revolution of the load, the outer race turns in the opposite direction by a small amount.

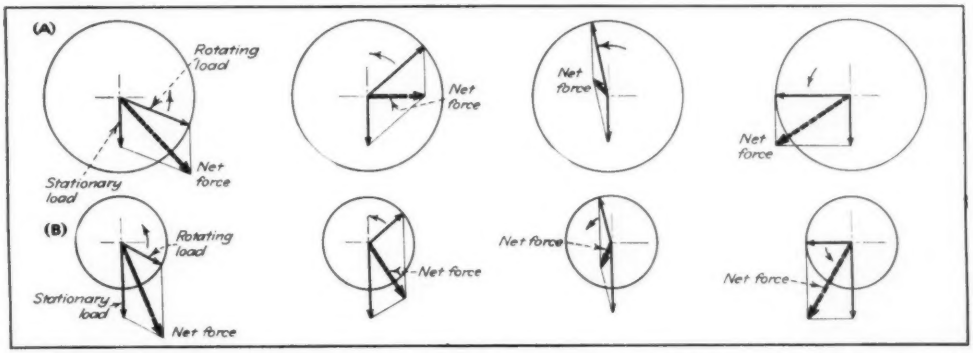


Fig. 4—Effect of rotating force on stationary radial load; (A) When larger, creep occurs; (B) when smaller, bearing merely rocks.

net pull of 48 lb in some designs of ½ hp motors. Net side pull per 0.001 in. of unbalanced gap, is shown in Table I for some commonly used sizes of motors.

Although usually neither the direction nor the amount of the net force caused by an unbalanced air gap is known, the fact that it does exist explains many instances where a small rotating force caused creep. The air gap pull counteracted so much of the normal bearing load that the net rotating load exceeded the stationary loading.

External Vibrations Cause Creep

Any rotating force that causes vibration of the device may produce creep of the bearing. In most instances, vibration forces are self-contained within the rotating element. Generally they are caused by mechanical unbalance, or intermittent loading as in a gas engine, for example. Also in electric machinery, a rotating unbalanced air gap, or a net rotating magnetic force produced by a rotor-stator slot combination may cause vibration.

Sometimes external vibration forces can produce bearing creep. For example, bearings of the accessories mounted on the rear cover of a common type of airplane engine are subjected to the vibration spectrum shown in Fig. 5. As shown in the spectrum, although the propeller speed reaches about 2,800 rpm maximum, higher order vibrations bring the equivalent speed up to 12,000 rpm. For instance, the chart shows a peak of 0.0125 in. at 6,300 rpm., this is the 2.5 order vibration for the engine at 2520 rpm. Because of the type of flexible mounting and the nature of the vibrating forces, usually the trace of vibration is circular or elliptical. Bearing mounted members, such as the armature of a starter, generator, or magneto within the accessories, follow the same vibration pattern. Force from the housing is transmitted into the accessory housing, through the bearing, into the revolving part. Thus the vibration force travels from the outside casing inward, instead of from the shaft outward as is the case of rotor unbalance.

For this engine, the inwardly-directed force of vibration reaches large values at certain speeds. The peaks of amplitude are at 1,000 (½ order), 2,800 (27/16 order) 6,300 rpm (2½ order). Converted into acceleration, the greatest force comes at 6,300 rpm. (0.0125″ amplitude) and is equivalent to 7 G. Where: Vibration amplitude VA = double amplitude, or total excursion, in in., then

$$G = \frac{(2\pi\ \text{rpm})^2}{60} \times \frac{VA}{386 \times 2}$$

For this example, then, the force necessary to make any part vibrate at 6,300 rpm is 7 times the weight of the part. Therefore any bearing mounted rotor on this cover is subjected to a vibration force of 7 times its own weight. A rotating force of this magnitude will cause creep if the outer race is free to move.

Outer Race Creep Torque

The torque acting on the outer race as a result of creep action can be many

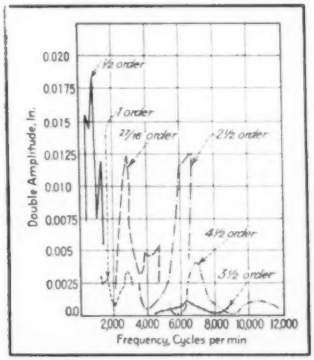


Fig. 5—Typical vibration frequency spectrum of motion of rear coverplate on airplane engine.

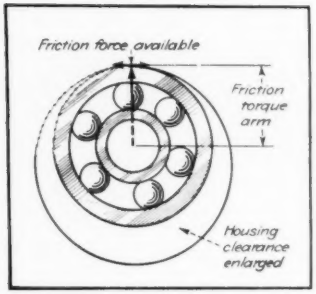


Fig. 6—Action of creeping outer race is similar to action of internal gear.

Fig. 7—A fan blade that is bent or loaded with dirt can cause high creep torques.

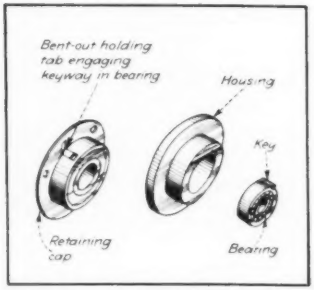


Fig. 8—Keyed race and housing prevents spin, but not creep in hard service.

times greater than any internal friction torque. Where the rotating or whirling force is large, forces of equal magnitude are required to prevent creep.

A creeping outer race is similar to an internal gear, as shown in Fig. 6. Teeth are replaced by friction. The maximum "tooth" side load or torque is equal to the radial force times the coefficient of friction times the bearing outer radius. Since the outer race at the point of contact does not move relative to the housing, the coefficient of friction is that for the parts at rest, not sliding. For clean surfaces, tests show the coefficient at rest is about 0.25. With fretting corrosion or other roughness, the value of static friction may be somewhat higher. Also since the diameters in contact are nearly equal, relatively large areas are in contact. Thus distributed dirt and imperfections help retard motion even though the unit force is small.

As an example of the large creep torques possible, consider a rotor weighing 20 lb mounted on the engine of 7 G acceleration. If the one 205 size bearing subject to creep accelerates half the weight (10 lb) the radial force through the bearing would be 70 lb. Taking the worst static coefficient as 0.4, average creep torque is $70 \times 0.4 \times 1.02 = 29$ in. lb.

Out-of-balance shaft loads can cause equally high creep torques. For example, a fan or blower such as shown in Fig. 7 might have a bent blade or be loaded with dirt. An unbalanced weight of only 1 ounce 4 in. away from the center revolving 3,600 rpm produces a torque of 38 in. lb on a similar 205 bearing. Where: F = force, lb; w = out of balance weight, lb; d = distance from center line, in, then

$$F = \frac{w\,d}{32.2 \times 12}\left(\frac{2\pi\ rpm}{60}\right)^2$$

Preventing Creep or Spin

Selection of a satisfactory method to prevent outer race motion depends upon the magnitude and type of force acting. The bearing can be positively restrained by keying, or a static friction torque can be provided that is greater than the creep torque. Strangely enough, keying is better for preventing internal friction spin than for preventing vibration creep.

Key. This seemingly obvious answer for all types of creep or spin does not always work. As shown in Fig. 8, a key between the bearing race and housing is a positive answer for outer race spin caused by internal friction. Many designers use this method for vertical applications. For relatively small forces and torques, a key also is satisfactory to stop vibration-induced creep. But for severe vibration forces, keys will not prevent damaging wear of the housing.

If the bearing is slightly loose in its housing, large rotating vibrational force can still rock the bearing about the key as a pivot or move the bearing up and down along the key, as shown in Fig. 9. Since motion is not prevented, fretting corrosion slowly wears away both bearing and housing. The sides of the key will also wear.

Selective Fit. To inhibit creep, bearing manufactures recommend that for loads where the housing rotates with respect to the direction of the load, the mean fit be from 0.0002 to 0.0004 in. tight. Typical values are shown in Table II. But these tolerances usually require a press or shrink fit that make free float impossible for the application and/or assembly. The AFBMA (Anti-friction Bearing Manufacturers Asso.) standards of recommended clearances for normal loads where the housing is stationary with respect to the direction of the load are shown in Table III. Usually, these are followed for free or sliding fit of the bearing in its housing. The mean fit is relatively loose, 0.0004 to 0.0008 in. and under rotating loads often creep will occur. If the forces are not too great, assemblies that happen to be on the snug side, 0.0001 to 0.0003 in. loose, will probably remain free from creep.

For small loads and moderate speeds, careful selection of bearings and housings to give a uniformly small clearance will be successful. The clearance should be about 0.0002 to 0.0003 in. loose for small size bearings 201 to 206. Tighter fits will give trouble at assembly; looser fits will creep rapidly.

Closely controlled clearance of small magnitude will not only keep the

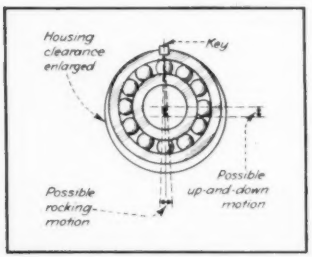


Fig. 9—With a loose fit, large vibrational forces will wear away key, bearing, and housing.

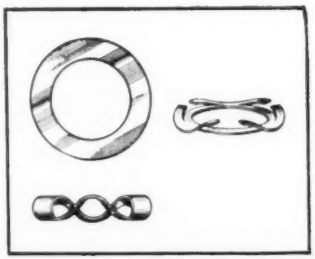


Fig. 10—Two types of spring washers that retard spin or creep by placing axial preload on bearings.

creep rate low, but the out-of-roundness of the outer race of the bearing may prevent any creep. If the housing pressure bringing the race back to roundness produces enough friction torque, creep will not occur. While careful selection of fit is not a positive cure for all conditions of vibration-induced creep, often it is an excellent corrective. Maintenance men report that housings that were badly worn by creep, do not wear after new, snugly fitted parts are installed.

AXIAL SPRING. Two types of spring washers that fit into the housing containing the floating bearings and produce an axial preload against the bearing are shown in Fig. 10. Such preventatives work well for both internal friction or vibration creep, if the vibration is not induced by large forces. Outer race motion is restrained by the friction torque provided by the spring contact points against the bearing. This friction torque is limited by (1) the axial force that can be generated by the spring, and (2) the capacity of the bearing to sustain the load. The spring has to be designed to be effective over the range of assembly tolerances, and yet when fully compressed not be so powerful that it taxes the bearing capacity. Generally, both these requirements result in a fairly light spring. While adequate for many applications, such springs are ineffective for certain conditions of large creep torque. For example, the 205 bearing might use a 50 lb axial spring, similar to those shown in Fig. 10. This is a good continuous axial load for this size bearing. Assuming a generous 0.4 friction coefficient, this will make available a 20 in. lb. friction torque. Actually, the friction torque that can be counted upon is only about 5 to 10 in. lb. as the coefficient of friction drops to be more nearly equal to the sliding value. This is because of the small area actually in contact, and the constant vibration and shift of the pressure surfaces.

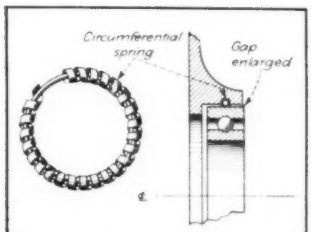


Fig. 11—Especially useful for preventing creep in difficult cases toroid type spring exerts uniform pressure on outer race.

Table II—Fits For Rotating Load

Excerpts from AFBMA Standards for housing dimensions—*ABEC-1 bearings for Loads Where the Housing Rotates With Relation To the Direction of the Load

OD, mm	Bearing OD, in.		Housing OD, in.		Mean Fit, Tight, in.
	Max	Min	Min	Max	
16	0.6299	0.6295	0.6292	0.6299	0.0002
24	0.9449	0.9445	0.9441	0.9449	0.0002
30	1.1811	1.1807	1.1803	1.1811	0.0002
35	1.3780	1.3775	1.3770	1.3780	0.0003
40	1.5748	1.5743	1.5738	1.5748	0.0003
47	1.8504	1.8499	1.8494	1.8504	0.0003
55	2.1654	2.1649	2.1642	2.1654	0.0003
68	2.6772	2.6767	2.6760	2.6772	0.0003
75	2.9528	2.9523	2.9516	2.9528	0.0003
80	3.1496	3.1491	3.1484	3.1496	0.0003
90	3.5433	3.5427	3.5419	3.5433	0.0004
100	3.9370	3.9364	3.9356	3.9370	0.0004

* Annular Bearing Engineers Committee.

Table III—Fits For Stationary Load

Excerpts from AFBMA Standards for housing dimensions, ABEC-1 Bearings. For Normal Loads where Housing is Stationary With Relation to Direction of Load

OD, mm	Bearing OD, in.		Housing OD, in.		Mean Fit, Loose, in.
	Max	Min	Min	Max	
16	0.6299	0.6295	0.6299	0.6303	0.0004
24	0.9449	0.9445	0.9449	0.9454	0.0004
30	1.1811	1.1807	1.1811	1.1816	0.0004
35	1.3780	1.3775	1.3780	1.3786	0.0005
40	1.5748	1.5743	1.5748	1.5754	0.0005
47	1.8504	1.8499	1.8504	1.8510	0.0005
55	2.1654	2.1649	2.1654	2.1661	0.0006
68	2.6772	2.6767	2.6772	2.6779	0.0006
75	2.9528	2.9523	2.9528	2.9535	0.0006
80	3.1496	3.1491	3.1496	3.1503	0.0007
90	3.5433	3.5427	3.5433	3.5442	0.0008
100	3.9370	3.9364	3.9370	3.9379	0.0008

CIRCUMFERENTIAL SPRING. The damaging creep of bearings in many difficult applications, such as for aircraft, can be prevented by the spiral spring shown in Fig. 11. The spring applies uniformly distributed radial force around the outer race of the bearing, and thus generates enough friction torque to overcome the creep torque. The toroid type spring is wound spirally from flat spring steel, approximately $\frac{1}{8}$ in. wide and 0.010 in. thick. The diameter of the spiral coil is held to close tolerance; when in the groove in the bearing housing, the inside surface of the spring protrudes into the bearing space about 0.010 in. When the bearing is inserted, the spring is compressed this amount. Forces of 100 lb. per circumferential inch are easily obtainable for 205 size bearings. The uniform pressure does impose additional load on the bearing. Overcoming of the friction force provides axial freedom.

With a friction coefficient of 0.1, the torque exerted by such a circumferential spring is $100 \times \pi \times 2.05 \times 0.1 \times 1.02 = 66$ in. lb torque on the outer race of a 205 bearing. This will prevent creep even under severe vibration forces. Note that a total of 600 pounds has to be applied to the periphery to be sure to stop its creep. Even with only 0.1 coefficient of friction, the 600 lb available force produces up to 12 times as much friction torque as is developed with the axial spring of 50 lb.

There are many other types of devices that attempt to prevent creep by exerting axial or radial force on the bearing. Their effectiveness for any particular design depends entirely upon how much friction torque is produced with respect to the amount of creep torque to be overcome.

Testing Vehicle Components With Strain Gages

- Stress measurements in service testing of heavy vehicles.
- Construction and calibration of a drawbar.
- Measurement of drawbar pull and of torque in drive shafts, starter motors, and transmissions.

ROBERT C. HIZER
Automotive Laboratory
Aberdeen Proving Ground

ACCURATE DETERMINATION of peak stress values and the range of stress variations in machine members under service operation is vital to the development of heavy duty vehicles.

The resistance wire strain gage is usually the most practical method of studying stress behavior under field conditions. It can be installed in almost any location and no structural modifications are necessary. It is small, light and mechanical vibrations or strains of almost any frequency can be measured. Properly applied, it is stable and will give reliable results indefinitely.

Information on the basic strain gage circuits and gage calibration has been published elsewhere (PRODUCT ENGINEERING, April, 1948 and the SR-4 literature of Baldwin Southwark Division, Baldwin Locomotive Works) so it will not be repeated here.

A practical circuit for strain gage field work is shown in Fig. 1. A galvanometer will only measure a few millivolts from a strain gage bridge circuit having 12 volts. Few galvanometers are this sensitive and they probably would have a slow response. For most applications this output is much too small, so for higher output voltage a vacuum tube amplifier must be used. The small direct current appearing at the galvanometer terminals could be amplified, but technical problems involving the stability of vacuum tubes in direct current must be considered. The alternating current system shown in Fig. 1 works much better. The usual battery is replaced by an audio frequency alternating current generator such as a vacuum tube oscillator. The unbalance voltage of the bridge circuit is amplified by a vacuum tube amplifier. Output of the amplifier is then rectified to direct current and this current can be used to deflect a galvanometer.

For calibrating purpose, precision wire wound resistors are used. These resistors come in various integral sizes. Several different sizes of resistors can be calibrated by calculating how much strain each resistance represents. These resistors can then be installed in a steel box along with a selector switch and two potentiometers, one for capacitance balance and the other for resistance balance. This calibrating box is connected into a strain gage circuit to produce several artificial strains of known magnitudes. Definite points on the galvanometer scale will then correspond to known strains. It was found that a 100,000 Ohm resistor artificially produced a change in leg *BC* equivalent to a strain of 35,000 psi.

After the bridge was balanced for capacitance and resistance, it was unbalanced by turning the resistance balance potentiometer slightly away from the balance point so that current would flow in the oscillograph galvanometer circuit. The effect of tension in leg

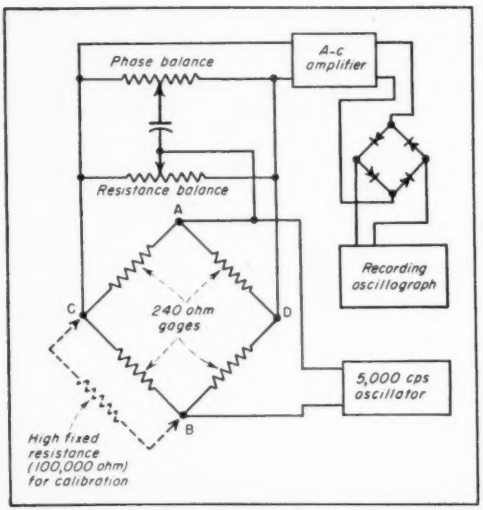


Fig. 1—Schematic of a strain gage amplifier a-c carrier voltage system. This circuit has a high output to deflect a galvanometer and avoids the stability problems of vacuum tubes.

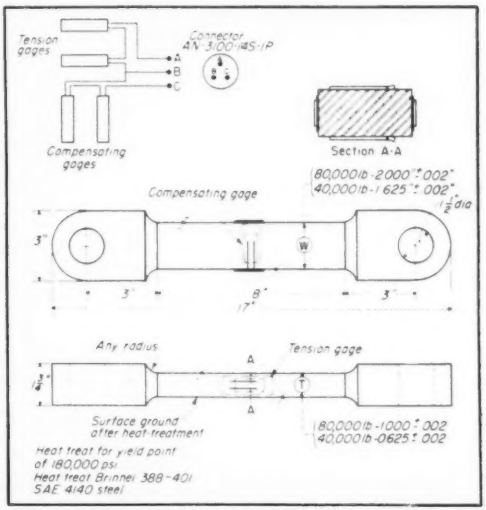


Fig. 2—Construction details of strain gage drawbars for 40,000 and 80,000 lb ranges. The circuit diagram for the strain gages is also incuded in the upper left hand corner.

BD will make either more or less current flow, depending on which direction the resistance balance potentiometer is turned. Compression causes a current to flow in a direction opposite to that caused by tension. Ordinarily the oscillograph galvanometer is adjusted so that the bridge balance point is at one end of the galvanometer scale; then unbalance due to the potentiometer will cause approximately half scale deflection. By doing this, the galvanometer will indicate either tension or compression. Fig. 1 shows a calibration box circuit.

The procedure for calibrating a strain gage installation on a small member is to place it in a tensile testing machine and record the strain on an indicator for different increments of load. Most strain indicators, such as the Baldwin Strain Indicator, measure strain in micro-inches per inch. The calibration factor can be found by dividing the load readings by the micro-inch strain reading. This will give the number of pounds per micro-inches per inch of strain. For instance, when it was found that a 100,000 Ohm shunt calibrating resistor produced an artificial strain indication of 1,175 micro-inches per inch, the calibration factor was multiplied by this figure to obtain the load to which the 100,000 Ohm calibrating resistor corresponds.

As an example, a 100,000 lb drawbar was set up in the tensile testing machine and a 60,000 lb load was applied; this causes an indicated strain of 1,236 micro-inches per inch. Dividing, the calibration factor was:

$$\frac{60{,}000}{1{,}236} = 48.6 \text{ lb per micro-inch per in.}$$

Multiplying the 1,175 micro-inches per inch we got from the 100,000 Ohm calibrating resistor, it was found that $1{,}175 \times 48.6 = 57{,}100$ lb. This was the load that the 100,000 Ohm calibrating resistor simulated.

Thus when actual measurements are about to be made, the 100,000 Ohm resistor is momentarily switched into the circuit, causing a deflection on the oscillograph galvanometer. This deflection will record the calibration as a trace on the paper at a definite distance from the zero point. In this instance, the distance from the zero point to the trace will represent 57,100 pounds.

The rating of drawbars is based on a stress of 40,000 psi where the strain gages are installed, thus an 80,000 lb drawbar will have a cross-sectional area of two square inches. Accuracies of one percent can be obtained if the strain gages are carefully and accurately applied. Construction of a drawbar is shown in Fig. 2. The strain gage circuit is included.

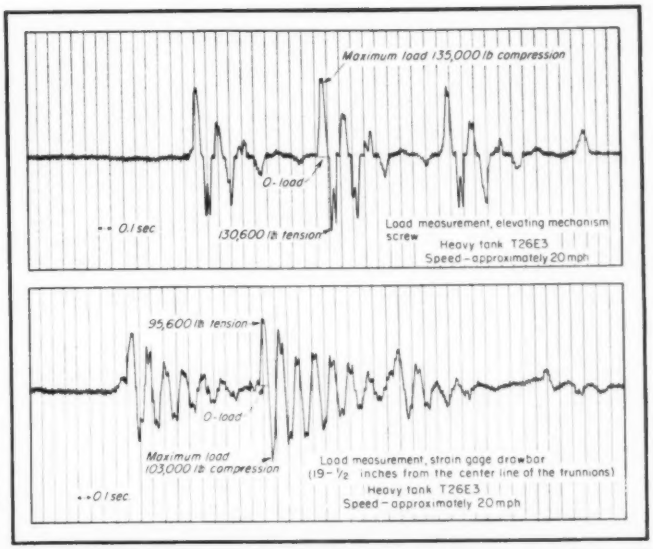

Maximum load 135,000 lb compression
0-load
0.1 sec
130,600 lb tension
Load measurement, elevating mechanism screw
Heavy tank T26E3
Speed – approximately 20 mph
95,600 lb tension
0-load
Maximum load 103,000 lb compression
Load measurement, strain gage drawbar (19 – 1/2 inches from the center line of the trunnions)
Heavy tank T26E3
Speed – approximately 20 mph
0.1 sec

Fig. 3—Dynamic loading record for an elevating mechanism screw on a heavy tank (above); load record from a strain gage drawbar mounted 19½ in. from the center line of the trunnions of a heavy tank; 20 mph speed, is shown by the bottom graph.

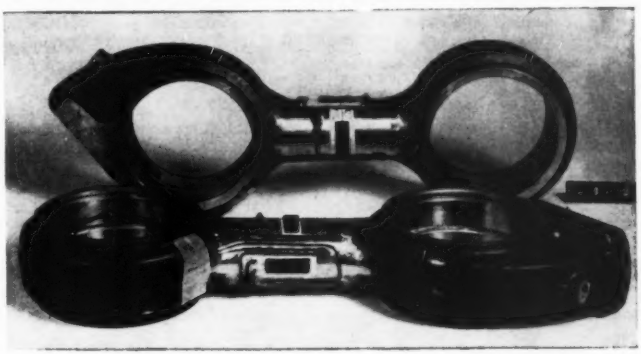


Fig. 4—Strain gages as installed on a front road wheel arm shackle of a heavy tank. Gages have not yet been waterproofed. This will be done by coating with Glyptal.

After the strain gage drawbar pull scale has been calibrated, it can be used as an instrument for measuring compressive or tensile loads under a variety of conditions.

Applications to Field Testing

The strain gage drawbar has been used successfully for measuring the drawbar pull of medium tanks, Fig. 3, for measuring the axial load in the elevating mechanisms of tanks, Fig. 3, and to measure the shock on front road wheel arm shackles, Fig. 4, on heavy tanks.

If strain gages are oriented on a round shaft, such as a drive shaft or an axle, at 45 deg angles with respect to the axis, they will indicate the twist of the shaft when a torque is applied. Usually it is desirable to arrange the gages in formations at diametrically opposite points on the shaft to compensate for bending, coming from the application of a transverse load at a distance from the bearings. In applications like these, the connection between the strain gages and the indicating equipment will have to come through a slip ring assembly.

During some cold starting tests of engines, it was desirable to measure the torque developed from the starter motor. This was accomplished by fabri-

Fig. 5—Dynamometer starter for recording cold starting tests of engines and power trains. Manufactured from a tank cranking motor. Four SR-4 gages are fixed to the arm.

cating a steel moment arm as shown in Fig. 5. Four resistance wire strain gages were cemented on the arm to form a Wheatstone bridge circuit. Two of the gages were for tension and two acted as temperature compensating gages.

Before actual tests could be run, the starter moment arm had to be calibrated. The starter arm was bolted on a starting motor and the motor was mounted in a frame in such a manner that it was free to rotate. The free end of the moment arm was rested on a knife edge unit placed on the platform of a weighing scale. Another arm, less strain gages, was bolted on the opposite side of the starter motor. A hydraulic jack was mounted under this second or dummy arm; by jacking up on this dummy arm a force or downward thrust was applied on the second arm. This thrust was registered in pounds on the weighing scale. The bridge circuit from the starter arm was connected to an amphenol connector and fed into a strain indicator. The torques applied on the starter arm caused the bridge circuit to become unbalanced. This unbalance was measured in micro-inches on the strain indicator. The difference in micro-inches of the initial setting and the unbalance was divided into the number of pounds that caused this unbalance. The result was the calibration factor. The number of pounds indicated on the weighing scale was multiplied by 3 because the distance between the jack head point and the knife edge point was 36 in.; thus the complete moment arm was 3 feet.

The starter arm was now ready to undergo actual tests. Fig. 6 shows the starter motor and the starter arm as it was mounted on the engine during the cold starting tests. Fig. 7 is an oscillogram of cranking tests; it shows the starter torque trace in pound-feet.

Final drive shafts of a medium tank with resistance wire strain gages applied are shown in Fig. 8. The leads from the bridge circuit had to be brought out through a slip ring assembly. Fig. 9 shows the final drive shaft with the slip ring assembly connected. Eight resistance wire strain gages were cemented on the shaft to form a Wheatstone bridge circuit. Four of the gages acted as tension gages and four were for temperature compensation. The gages were applied at a 45 deg angle and diametrically opposite. The tension gages were placed opposite to one another and the compensating gages were placed in a like

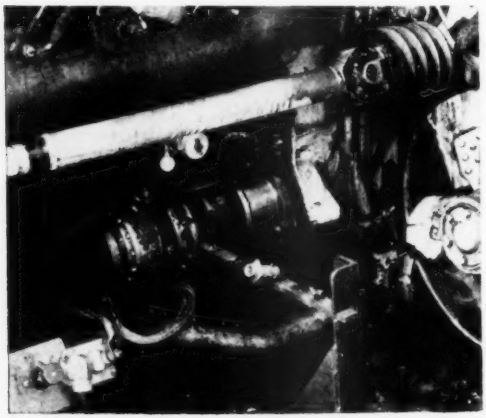


Fig. 6—Dynamometer starter as installed in a tank preparatory to cold starting tests on engine and power train.

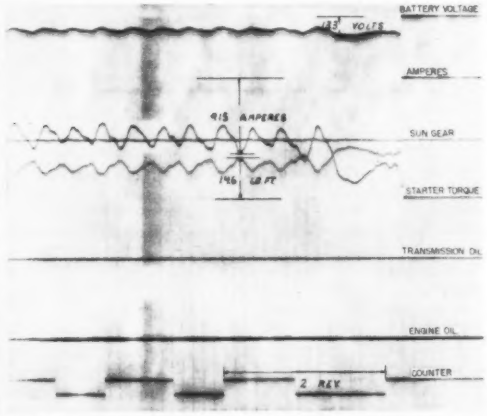


Fig. 7—Typical oscillogram of cranking test at —63 F with Reo —15 oil in engine, transmission and differential drained.

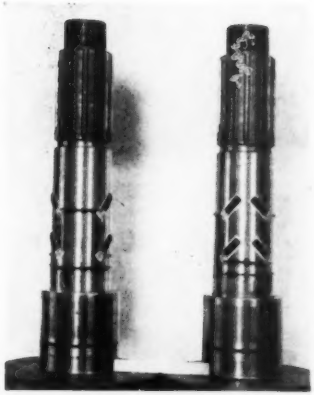


Fig. 8—Final drive shafts of a medium tank showing strain gages mounted for torque indication. Not yet oil proofed.

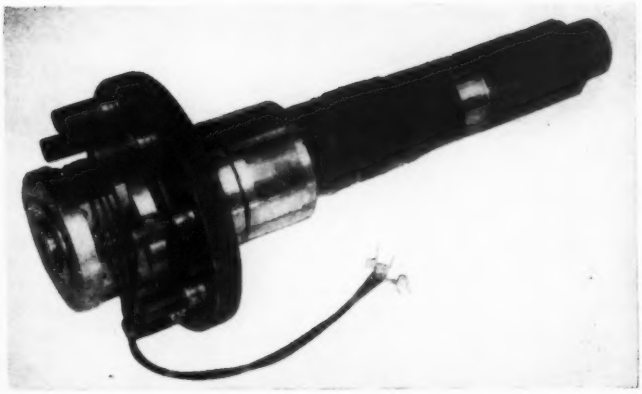


Fig. 9—Final drive shaft torquemeter showing slip ring assembly and Glyptal coating over strain gages. This arrangement was not satisfactory because of the slip ring connection. Particles of dirt and moisture on the contacts caused erratic readings.

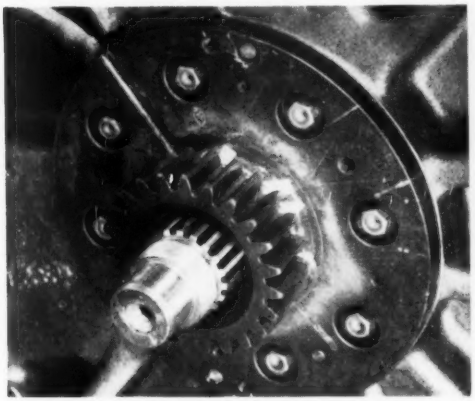


Fig. 10—Strain gages mounted on the collar of a transmission sun gear for torque measurement. Mounting was difficult because gages had to be bent to fit on the fillet.

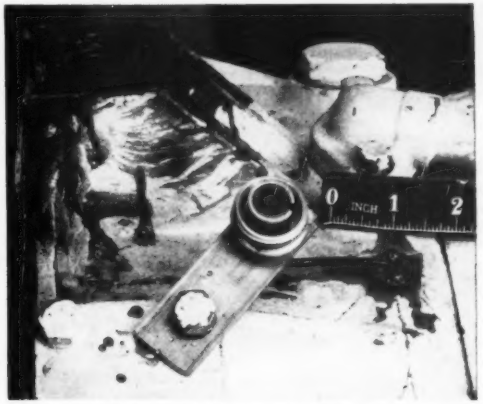
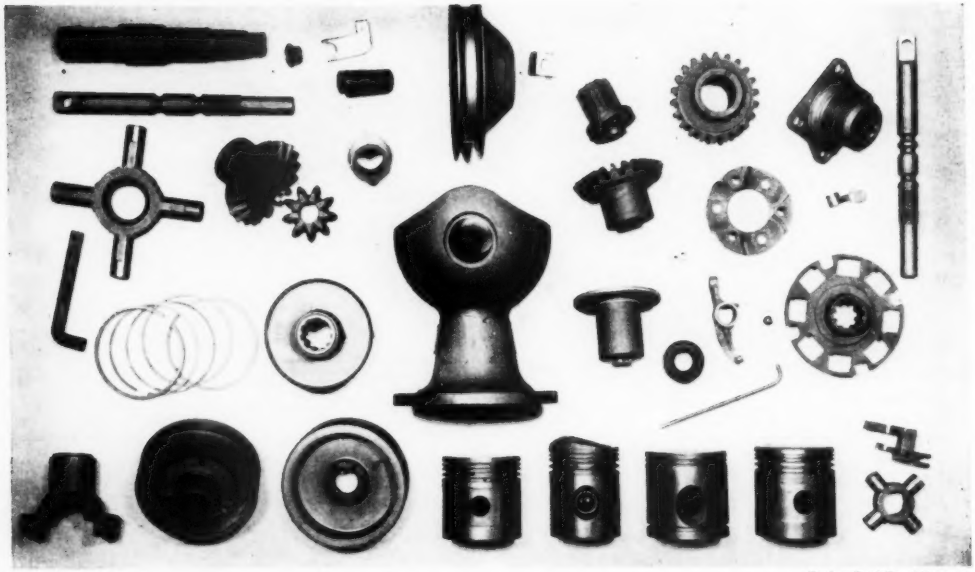


Fig. 11—External connection for strain gages mounted on the sun gear in Fig. 10. Sealing gages and leads is a problem on these applications. Hot oil frequently seeps through the cement.

manner. The slip ring had four silver rings and sixteen carbon brushes; each lead from the bridge circuit was connected to four carbon brushes which rode and made contact to one particular ring. The four lead wires coming from the slip ring were soldered to an amphenol connector. Two final drive shafts and slip ring assemblies were built up, one for the left and one for the right final drive.

The final drive shafts were calibrated in a like manner to other calibrations for torque; a calibrating arm was used and known values in pounds were applied. The unbalance of the bridge circuit was measured in microinches on a strain indicator. Test runs were made with the shafts installed in the tank. Some data was compiled during these runs but trouble was encountered in the slip ring assembly. Dust, dirt and moisture would find its way into the assembly and collect on the silver rings and the brushes. This would cause erratic readings on the measuring meters. Some of the gages shorted out because hot oil seeped through the Glyptal coating covering the gages.

To measure the input torque of a torquematic transmission some resistance wire strain gages were oriented on a sun gear, Fig. 10, which is a part of the transmission. Results were difficult to obtain because of the manner in which strain gages had to be applied around the collar of the gear to measure the greatest amount of torque. The strain gages were cemented on the collar at a 45 deg angle. To form this angle the gages had to be bent, and many gages were spoiled in this bending process. Several became shorted after application. The main difficulty in applying the gages was that the lead wires would break through the paper backing of the gage at the bending point. After many attempts, eight strain gages were finally applied that were not shorted. A second difficulty was to find a cement that would hold and protect the strain gages from the heat and hot oil spray present in the transmission. Thinned Duco cement was finally used. The sun gear was calibrated by applying known torques in pounds to a calibrating arm and measuring the unbalance of the bridge circuit in microinches shown on a strain indicator. Fig. 11 shows the amphenol connector mounted on the transmission case so that cable connections could be made to the bridge circuit on the sun gear. Fig. 7 shows a typical oscillogram.



Parker Rust Proof Company

Fig. 1—Ferrous parts of every shape and size have been protected against scuffing with manganese iron phosphate coatings.

Chemical Scuff Resistant Coatings

There are several types of chemical treatments applied to iron and steel parts to reduce scuffing and wear. Test data and performance evaluate manganese iron phosphate, iron oxide and iron sulfide coatings, for effectiveness, application, and ease of production.

GEORGE BLACK
Metal Finishing Methods Consultant

CHEMICAL METHODS for producing scuff resistant coatings are considered when the application does not justify the higher cost, additional time and complicated procedure required for electrodeposited metallic coatings. In addition, chemical coatings have specific property advantages.

Chemical coatings designed to reduce or prevent wear caused by metal to metal contact of moving parts should fulfill the following requirements:

1. Must be sufficiently elastic under pressure of mating parts, thus reducing stresses.
2. Should be sufficiently hard to assure mild abrasive action. If coating is too soft it will wear off in a comparatively short time; if too hard excessive heat can be generated.
3. Must prevent fusion from heat.
4. Should absorb oil to improve lubrication.
5. Should form a porous, etched surface to provide an escape for wear particles and form minute reservoirs for oil.

Three types of chemical scuff resistant coatings have been developed: (1) Iron sulfide; (2) iron oxide; and (3) phosphate coatings. The iron sulfide surface is produced by immersing parts in a hot aqueous bath of 50 percent sodium hydroxide by weight, to which 1 percent of powdered sulfur has been added. This coating can set up protection against heat fusion during break-in periods, but is usually too soft and wears off too quickly. The ferrous oxide method involves heating in a furnace to approximately 1,050 F, and then introducing steam. Ferrous oxide has been successfully applied to a variety of cast iron parts, including piston rings and cam followers. Cast iron farm tractor tappets which had been tested in the laboratory under a wide range of operating conditions without indications of failure, were reported by one manufacturer to be failing in the field after comparatively short periods of use. It was found that recommended tappet clearances were being disregarded, and the abusive treatment caused by farm operations led to failure. A ferrous oxide treatment on the face of the tappets permitted the tappets to be operated with the clearances which the users seemed to prefer. Fig. 2 is a comparison of two tappet faces, one untreated, the other coated with ferrous oxide. Unfortunately, ferrous oxide cannot be used on hardened steel parts, since the high temperature at which the coating is produced anneals the metal.

Phosphate Coatings

Of the various chemical and other surface treatments used for the prevention of scuffing, the phosphate treatments appear to be most effective. In general, there are two types of phosphate treatments: (1) zinc phosphate coating—produced by immersion of the parts in a proprietary solution of ferrous and zinc dihydrogen phosphates, together with nitrates—the resultant coating is shallow and fine-

Table I—Results of Direct Scuff Resistance Tests on Case Hardened Gears*

Coating	Solution	Operating Conditions	Mean Scuffing Load, lb per in. of face width	Scuff Resistance Ratio of Treated to Untreated
Untreated			3,300	1.00
Zinc Phosphate	Ferrous and zinc dihydrogen phosphates plus nitrates.	10 min, 180–185 F	4,500	1.36
Prolonged Zinc Phosphate	Ferrous and zinc dihydrogen phosphates plus nitrates.	30 min, 180–185 F	5,570	1.69
Zinc Phosphate	Zinc dihydrogen phosphate with an accelerating agent	5 min, 167–185 F	4,960	1.50
Cool Zinc Phosphate	Zinc dihydrogen phosphate plus nitrate	20 min, 110–120 F	5,310	1.61
Manganese iron Phosphate	Ferrous and manganese dihydrogen phosphates.	45 min, 204–208 F	6,770	2.05
Manganese iron Phosphate		30 min, 208–212 F	6,940	2.10
Accelerated Manganese iron Phosphate		15 min, 190–195 F	6,870	2.08

*Gears were run under light load until the oil temperature became constant, and the load was then increased in steps, beginning with 1,450 lb per in. face width, and increased in steps of 306 lb per in. face width, each load being maintained for five minutes. This was continued until scuffing occurred. Research carried out by the Automobile Research Committee of the Institution of Automobile Engineers (Great Britain).

for Ferrous Parts

grained; and (2) manganese iron phosphate coating—produced by immersion in a proprietary solution of ferrous and manganese dihydrogen phosphate. The result is a comparatively deep and coarse grained nonmetallic oil-absorptive coating, consisting chiefly of iron and manganese phosphates. The uniformity of penetration of the surface by the phosphate coating and its affinity for oil are believed to be its chief properties in reducing wear.

Because of this effect, the manganese iron phosphate treatment gives the greatest protection against scuffing. This is demonstrated in Table I, which gives results of direct scuffing tests on case hardened gears. Assigning a scuff-resistance ratio of 1.00 to the untreated gears, the manganese iron phosphate coatings gave the highest ratios, 2.05, 2.10, and 2.08. The accelerated phosphate treatment listed at the bottom of the table is closest to the proprietary solution in actual use in this country.

In the same series of tests from which Table I was compiled, caustic sulfur, electroplated tin and collodial graphite coatings were tried on the gears. They showed low ratios—1.29, 1.00 and 1.21 respectively. Since details of their application are not known, these values are not listed in the table.

Application

Of the various chemical treatments for scuff resistance, manganese iron phosphate is considered the most important because of effectiveness, diversified use, low cost, ease of control and simplicity of application.

Parts to be phosphate treated are cleaned by immersion in emulsified petroleum type cleaners at room temperatures for 3 to 5 minutes and then spray rinsed at 120-140 F. Vapor degreasing, using trichlorethylene or perchlorethylene vapors, or various commercial alkaline cleaners can also be employed. A final spray rinse in hot water should be included after alkaline cleaning, but can be omitted if vapor degreasing is used.

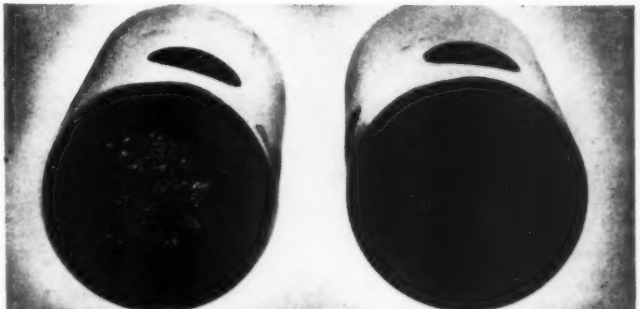
After cleaning the parts are immersed in a proprietary manganese iron phosphate bath maintained at approximately 210 F for 15 to 20 min. The resultant chemical coating is then rinsed in hot running water and dipped in water soluble oil for 30 to 45 seconds.

With suitable accelerators and oxidizing agents, coating formation can be completed within 2 to 5 minutes of immersion. In addition, special spray methods have been developed so that production coatings can be applied in as little as 5 seconds. The simplicity and speed of this treatment have contributed to its wide use.

The thickness of coating obtained by this treatment depends to a large extent on the method of cleaning, the type, hardness and surface finish of the base materials. Manganese iron phosphate coatings have thickness limitations more narrow than plated coatings. For scuff resistance, phosphate coatings are usually between 0.0002 and 0.0003 in., representing a coating weight of approximately 150 to 700 milligrams per square decimeter (mg per sq dm), when produced by immersion. Coatings thicker than 0.0004 in. cannot be produced.

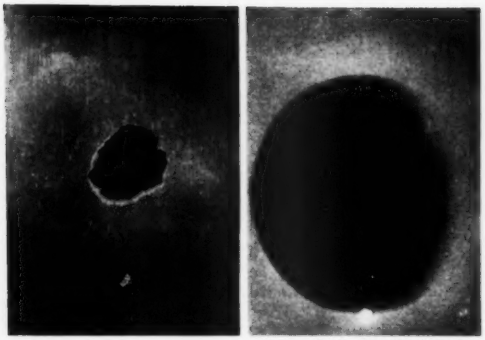
Tests and Performance

Laboratory and installation tests have been undertaken to demonstrate how the manganese iron phosphate



The Eaton Manufacturing Company

Fig. 2—Untreated valve tappet on farm tractor, left, failed after short periods of service. Tappet face coated with ferrous oxide, right, made normal service possible despite users disregarding recommended clearances.



Parker Rust Proof Company

Fig. 3—Increased lubrication of surfaces coated with manganese iron phosphate is shown by the comparative spreading rate of a drop of oil on an untreated (left) and treated steel surface.

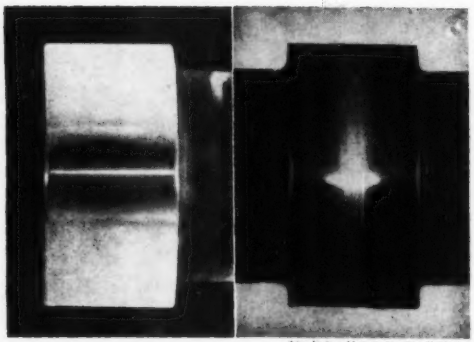


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Fig. 4—Steel cams untreated (left) and treated (right) with manganese iron phosphate. These correspond to conditions shown in photomicrographs (A) and (B) in Fig. 5.

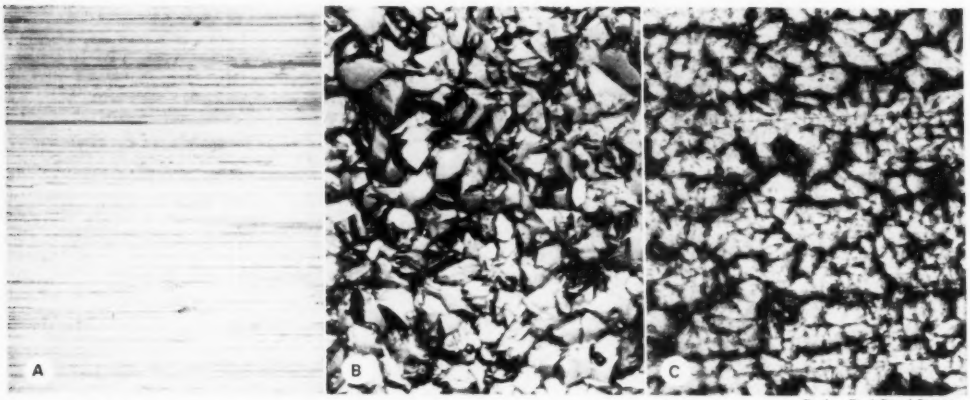

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Fig. 5—Porosity and depth of penetration of the phosphate coating is shown in these 100X photomicrographs: (A) steel cam surface as ground; (B) cam surface treated with manganese iron phosphate; (C) treated cam after coating is chemically removed.

treatment prevents scuffing and reduces wear. Primarily, it increases the lubrication of the surface because of its high affinity for oil. Fig. 3 shows the extent to which this affinity for oils aids lubrication.

In addition to "holding" oil, the porous surface acts as automatic reservoir, spreading the lubricant equally on all portions of the surface. Fig. 4 shows two cams, one untreated, the other coated with manganese iron phosphate. Photomicrographs of these cam surfaces taken at 100X, Fig. 5, show the untreated cam surface as ground, the cam surface treated with manganese iron phosphate, and the treated cam surface from which the coating has been chemically removed. In the second photomicrograph, the porous surface is plainly visible. In the third view, even though the coating has been removed, the permanent effect of the treatment—the etched surface—can be seen.

Parker Rust Proof Company

Fig. 6—Metal-to-metal contact of bearing surfaces during "break-in" periods is prevented by the 0.0004 to 0.0006 in. addition to cast iron piston diameters caused by phosphate treatment, as shown in this cross-section 100X photomicrograph.

Another important function of the phosphate coating is the prevention of metal to metal contact during break-in periods. The cross section of a treated cast iron shaft, shown in Fig. 6, illustrates the manner in which an integral layer of manganese iron phosphate separates metallic surfaces. Increase in diameter is generally 0.0004 to 0.0006 in. in such parts as finished pistons.

These properties—ability to retain oil, aid in lubrication, prevent metal to metal contact, permit rapid break-in without scuffing or welding and increased resistance to wear—have been proven in performance tests. In these, treated cast iron pistons were run in gasoline engines on dynamometers for tie-up and performance tests. In the performance or normal endurance test, after 28 hr of run in with light load, the piston was run for 164 hr on cycle 2,750 and 3,800 rpm. For the tie-up test, in which "seizing" or welding would be failure, no run in was given. Operation was conducted for 15 min. at 1,000 rpm and then for 2 hr at 4,000 rpm with wide open throttle. The pistons in both tests

were "broken in" with no evidence of scuffing or welding.

In preventing wear, the manganese iron phosphate treatment effects an additional economy which is not apparent. During machining and polishing of metal surfaces, burrs result which adhere to the finished metallic surface. Because of the increased unit area exposed to the phosphating solution by these metal burrs, they are almost completely dissolved and removed during treatment. The extent to which this action takes place is demonstrated by comparing the untreated and treated surfaces in Fig. 7. Not only is wear reduced, but the cost of mechanical cleaning is reduced.

Manganese iron phosphate treatments reduce metal finishing operations and wear in almost any functional ferrous metal part. This is demonstrated in Fig. 8, showing four engine valve stems. The first, *A*, shows the scuffing on a valve stem with a 5 micro-inch finish, run in a burnished finish guide without surface treatment. In an apparent attempt to provide a better "grip" for lubricants the valve stem was finished rougher, 30 to 40 micro-inches. Run in a burnished finish guide without surface treament, it became badly scuffed, as shown in *B*. Then a 5 micro-inch stem was run in a rough-reamed guide coated with manganese iron phosphate. This combination ran without scuffing, but showed heavy bearing marks, *C*. Finally, a rougher finish stem, 30 to 40 micro-inches, was run in a rough reamed guide that was phosphate coated. It can be seen in *D* that this combination showed no scuffing and practically no bearing marks. Thus, fine and close tolerance finishing operations were made unnecessary.

Uses

Experiments have shown that the manganese iron phosphate surface permits rapid break-in of moving parts without scoring or scuffing, and that it effectively reduces wear. This treatment has been applied successfully to cylinder liners, piston rings, pistons, valve tappets and rocker arms, camshafts, gears, pulleys and similar automotive, farm vehicles and aircraft parts.

The application of manganese iron phosphate to moving parts is particularly useful when high pressures and high rubbing velocities are involved. This coating is applied to hardened rear axle parts, including sliding clutch gears, idler pinions, differential side gears and side pinions, differential spiders and other ferrous parts that have surfaces in rubbing contact. The phosphate coating also prevents scoring when inserting hardened pins in such parts as forged I-beams and knuckles.

In automobile engine cylinder barrels, no attempt need be made to obtain a low profilometer reading, when phosphate coating is used. In aircraft applications, hydraulic cylinders employ phosphate-treated steel cylinders rubbing against anodized aluminum or untreated steel barrels. In grease-lubricated aircraft gear assemblies steel shafting is treated with manganese iron phosphate.

Perhaps only partly related to scuff resistance is the use of phosphate coatings to facilitate deep drawing and extrusion of steel. Phosphate coating for lubrication of steel prior to drawing reduces friction, permits faster drawing operations, reduces power consumption and increases tool and die life. A thinner coating than required for normal scuff resistance, not over 40 mg per sq dm, is required. In a recent test 18 gage steel disks 35.5 in. in diameter were phosphate coated and drawn into washing machine tubs without any splits or breakers. It was impossible to draw tubs from this same grade of steel without splits and breakers when the phosphate was omitted.

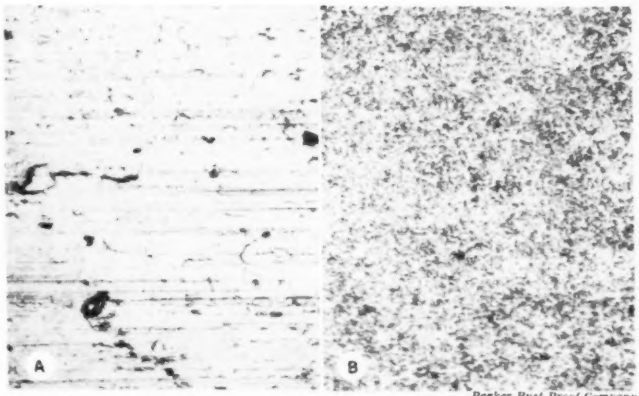

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Fig. 7—Burrs remaining on metallic surfaces after machining or abrasive operations are attacked preferentially during the phosphate treatment. Photomicrographs at 100X show ground surface of cast iron piston (A), and similar surface after phosphate treatment (B). Removal of such irregularities reduces wear on bearing surfaces.

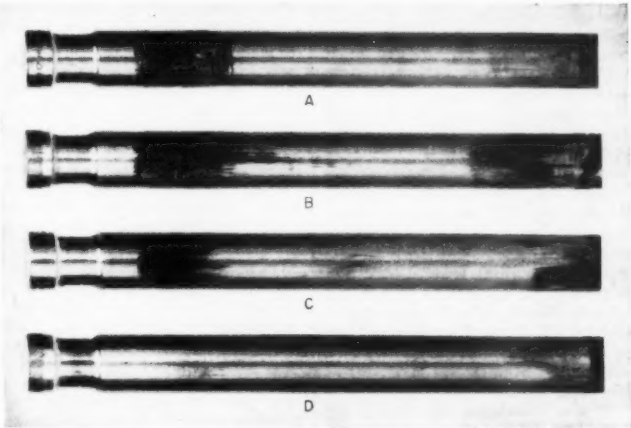

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Fig. 8—Phosphate treatment reduces metal finishing operations and wear on functional parts: (A) engine valve stem with 5 micro-inch finish run in burnished guide with no treatment; (B) 30 to 40 micro-inch finish valve stem run in same guide; (C) 5 micro-inch finish valve stem run in rough reamed phosphate coated guide; (D) 30 to 40 micro-inch finish valve stem run in rough reamed phosphate coated guide.

Significant Strength of Steels In the Design of Machine Parts—I

Quantitative evaluation of the effect of individual factors on the determination of allowable strength to be used in the design of machine parts. Factors discussed include static loading, alternating loading, combined loading, surface finish, and hardness. Constructions of significant strength diagrams are described and then applied to the different types of load.*

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TO OBTAIN economically proportioned structural parts that will give satisfactory performance, two factors must be determined in design. (1) Significant stress; that is, the stress impressed by service loads, assembly conditions or by fabrication that is most likely to cause failure of the part. (2) Significant strength; that is, the maximum external load that the part in its fabricated form can sustain under specified conditions.

Conventional design practice employs one of two criteria for defining the significant strength. The first, derived from experience with successful and unsuccessful designs, defines significant strength as the maximum stress that the parts are known to sustain without failure. These values are usually found in design codes; their reliability depends on individual interpretation and experience.

The second criterion uses a value related to the ultimate strength or the yield point of the material. Ultimate strength is the more readily measured quantity. It represents the optimum strength that the material can exhibit and is related to all other measurable quantities pertaining to strength.

Ultimate strength alone is not a correct index of strength. The strength of a member varies with many factors such as: Hardness of the material, size of the member, surface conditions, surface treatment, type of loading, and life expectancy.

When knowledge concerning the way these factors affect the ultimate strength is insufficient, it may be convenient to group all their individual effects under a common index termed Factor of Safety. This factor divided into the ultimate strength gives a resultant value often tacitly accepted as the significant strength. Since design practices are predicated on the absence of failure, the significant strength thus derived is usually on the conservative side. For severe service conditions, the significant strength thus derived may be approximately correct, but would be decidedly on the conservative side for a more favorable set of conditions.

A more rational approach would still be to employ ultimate strength as the basis for the derivation of the significant strength. But instead of indiscriminately grouping into one index all the factors affecting the ultimate strength, the designer should evaluate quantitatively the effect of each individual factor pertaining to the particular part and to the conditions under consideration.

A design value for the significant strength so derived is strictly applicable to the part under consideration and to the loading conditions to which the part would be subjected in service.

Effect of Mode of Loading

Applied external loads may be: Static; alternating; or a combination of static and alternating loads, Fig. 1. For each the criterion of significant

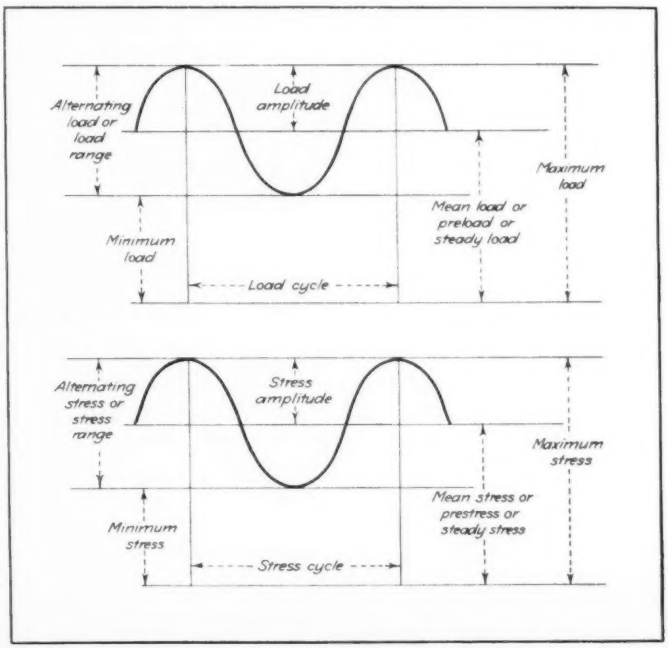

Fig. 1—Physical significance of common terms used to define applied external loads.

*The material in this article has been abstracted from the authors' manuscript "Factors of Stress and Strength," which will soon be published in book form.

strength is different, because each mode causes a different type of failure.

STATIC LOADING. For static loading, the yield point or yield strength of the material should be taken as the significant strength because under such loading failure exhibits itself as permanent distortion, which results from stresses greater than the yield point of the material. Distortion occurs over a considerable portion of the member in the region of failure. In a conventional tensile test specimen, the phenomenon is commonly known as "necking".

When yielding occurs in low strength steels, there is a noticeable decrease in the load necessary to cause further deformation. In high strength steels, a slight increase in load causes a relatively large increase in further deformation. For soft steels, the load per unit of cross-section at which a marked increase in deformation occurs with a slight decrease in load is known as the yield point of the material.

For high strength steels, the point of yielding (yield strength) is arbitrarily taken as the stress corresponding to the load that causes an extension 0.1 to 0.2 percent larger than would be anticipated from the previous rate of deformation. Hence, for design purposes the yield point or the yield strength is generally taken as the safe upper limit (the significant strength), since the large deformation at higher stress would distort the part excessively.

When a part would perform satisfactorily in service even though slightly distorted, the ultimate strength might be taken as the significant strength. Since this condition, however, is a rare occurrence and yielding generally occurs before final rupture, the yield point or yield strength should ordinarily be taken as the significant strength for static loading.

Where the speed of load application affects only the magnitude of the applied stress, a single impact can be regarded as a special type of static loading. In some instances the yield point of the material is increased when a single load is applied rapidly to induce failure. In the absence of more extensive data, however, and for the purpose of conservative design, the use of the conventional yield point will suffice as the significant strength.

ALTERNATING LOADING. Where the load is repeated a large number of times, failure occurs as a brittle fracture without any evidence of yielding. The failure usually originates as a crack at a localized point on the surface. Under successive loading the crack propagates itself through the section, until not even a single load application can be sustained and instantaneous failure occurs.

The surface of the fatigue zone through which the crack propagates itself exhibits a typical brittle fracture. The appearance of its surface is usually smooth and velvety as a result of the successive pressing and rubbing of the cracked faces. In contrast, the instantaneous zone is coarse and crystalline because of the rapid rate at which failure occurs when the uncracked portion is unable to sustain the load.

In alternating loading, failure usually occurs at a stress below the yield point of the material. The highest unit stress that the member can sustain for at least 10 million cycles without failure is termed the endurance limit of steel. Ten million cycles is arbitrarily taken because in the majority of designs a steel part that can withstand this number of cycles without failure will last indefinitely. For this reason, the endurance limit is taken as the significant strength for alternating loading.

COMBINED STATIC AND ALTERNATING LOADING. In combined static and alternating loading, some value between the endurance limit and the yield point of the material is taken as the significant strength. Several methods have been proposed to determine the significant strength for the various combinations of static and alternating load.

The most commonly used method employs an adaptation of the so called Modified Goodman Diagram, Fig. 2, in which the maximum stress S_M is plotted as the ordinate and the mean stress S_m as the abscissa. The diagram is constructed by laying off the ultimate strength S_u on the ordinate corresponding to the ultimate strength value on the abscissa, and laying off the endurance limit on the zero mean stress ordinate. A straight line between these two points gives the allowable stress (significant strength) for any value of mean stress.

Note that the diagram, Fig. 2, permits the maximum stress to exceed the yield point. As mentioned before, the yield point rather than the ultimate strength should be taken as the significant strength. Fig. 3 shows the diagram with this change incorporated; it shall be termed the Significant Strength (or Allowable Stress) Diagram. For alternating loading only (zero mean stress, point K on the abscissa), the endurance limit of the material (point A on the ordinate) is taken as the significant strength. When the loading is combined static

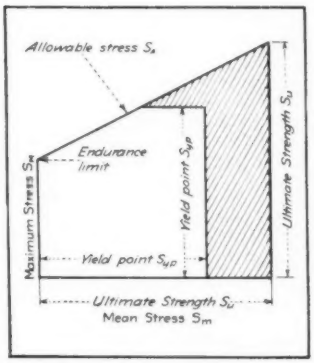

Fig. 2—Adaptation of the modified Goodman diagram for determining significant strength in combined static and alternating load.

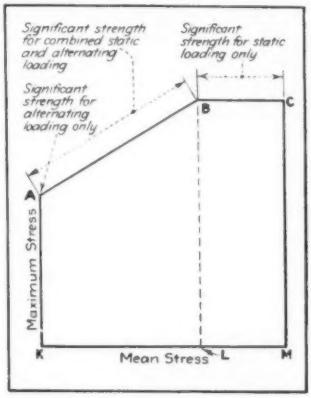

Fig. 3—Significant strength diagram derived on the basis of bending and direct tensile tests.

and alternating (mean stress between points K and L), the significant strength is defined by the sloping line AB. For combined loads giving mean stresses higher than before (mean stress between L and M), the significant strength is represented by the yield point.

APPLICATION OF THE SIGNIFICANT STRENGTH DIAGRAM TO VARIOUS TYPES OF LOAD. The diagram shown in Fig. 3 was derived on the basis of bending and direct tensile tests. To derive a diagram of general application, other types of loading, such as, compressive and torsional, must be considered. J. C. Smith has shown that the allowable stress (Significant Strength) increases directly with the mean stress for all values of compressive mean stress up to approximately 0.8 of the ultimate strength for low

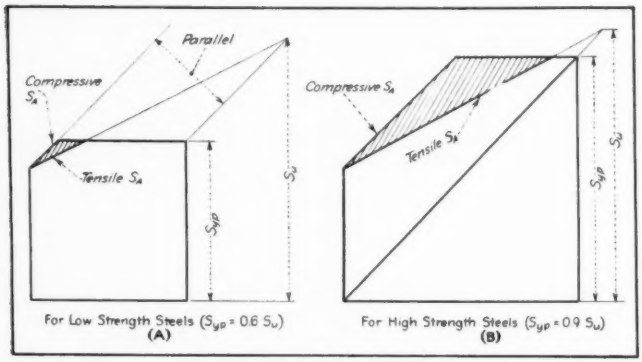

Fig. 4—Comparison between the maximum tensile stress and the maximum compressive stress. (A) For low strength steels. (B) For high strength steels.

strength steels, and 0.9 for high strength steels.

For low strength steels, Fig. 4(*A*) shows a comparison of the allowable stress when the mean stress is tensile and when the mean stress is compressive. It is apparent that in the low strength steels the discrepancy between the tensile and compressive allowable stresses is insignificant. Fig. 4(*B*) gives a similar comparison for high strength steels. For the high strength steels, the allowable stress in tension is considerably less than the allowable stress in compression. Since the error is on the conservative side, the tensile diagram shown in Fig. 3 can safely be used in compression.

Experimental evidence derived from fatigue tests of ductile metals in torsion indicates that the allowable stress decreases as the torsional mean stress increases. That is, a diagram of similar shape to that of Fig. 3 for tensile mean stress could be used for the condition of torsional mean stress. To avoid the necessity for two diagrams (tensile and torsion), it is convenient to use the tensile stress diagram and convert shear stresses into equivalent tensile stresses. This conversion can be accomplished through the Van-Mises Hencky Theory (constant energy of distortion theory), which gives the equivalent tensile stress as $\sqrt{3}$ times the shear stress.

For biaxial stresses the same procedure as used for torsional stresses can be applied. That is, stresses can be expressed in terms of the equivalent tensile stress by means of the distortion energy theory.
Where

S_e = equivalent tensile stress
S_x and S_y = normal stresses
V_{xy} = shear stress

$$S_e = \sqrt{S^2_x - S_x S_y + S^2_y + 3V^2_{xy}} \quad (7)$$

The justification for this conversion has been demonstrated by H. J. Gough and H. V. Pollard. They have indicated that for ductile materials the distortion energy theory fits the experimental results more satisfactorily than the more conservative maximum shear theory.

For triaxial stresses no experimental data are available to justify a similar conversion to equivalent stresses. J. Marin states that the strain energy theory results in more conservative values than the distortion energy theory and probably for triaxial stress application the former should be used.

Effect of Surface Finish

For the purpose of discussing the effect of surface finish on the significant strength, all surfaces can be classified into four broad categories: Ground, machined, hot rolled, and as-forged. These four categories are selected because they are the most common surfaces used in manufacturing. Their effect on significant strength is shown in Fig. 5. The endurance limit of ground parts can be taken approximately as 50 percent of the ultimate, while for as-forged surfaces the endurance limit can be less than 10 percent of the ultimate. Intermediate surfaces, such as hot rolled, turned, or machined are characterized by endurance limit values between 10 and 50 percent of the ultimate.

The ground surface category includes all types of surface finish that do not affect the endurance limit by more than 10 percent. O. J. Horger has shown no variation in the endurance limit between ground, polished, and super-finished soft steel specimens. G. A. Hankins, M. L. Becker, and H. R. Mills indicated that the variation in the endurance limit between specimens finished with fine and coarse emery paper was 3 percent for a steel of 118,000 psi tensile strength and 11 percent for a steel of 138,000 psi strength.

No significant difference between ground and polished specimens of low-strength steel was found by H. F. Moore and J. B. Kommers. In view of this evidence, all data from polished, ground, honed, lapped, and superfinished specimens are included in the ground surface category and plotted against the tensile strength, Fig. 5. J. A. Broadston reports that these methods of finishing give a surface with a maximum profilometer reading of 100 micro-inches.

In the machined surface category, O. J. Horger found no difference in endurance limit between rough and finished machined specimens of soft steel; the endurance limit of both being 10 percent less than that for

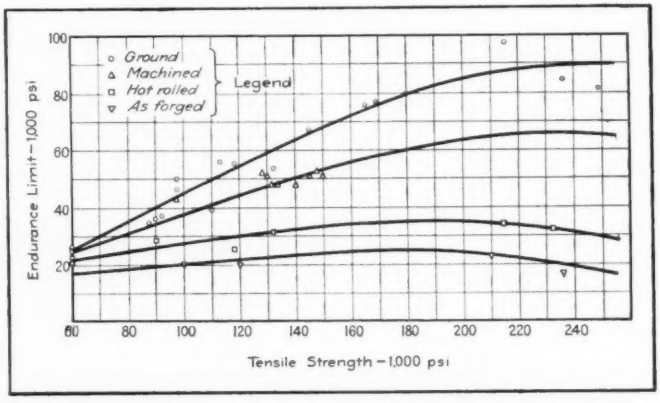

Fig. 5—Relationship between the endurance limit and the tensile strength for unnotched steel specimens loaded in reversed bending. Curves give comparative data for steel parts having ground, machined, hot rolled, and as forged surface finishes.

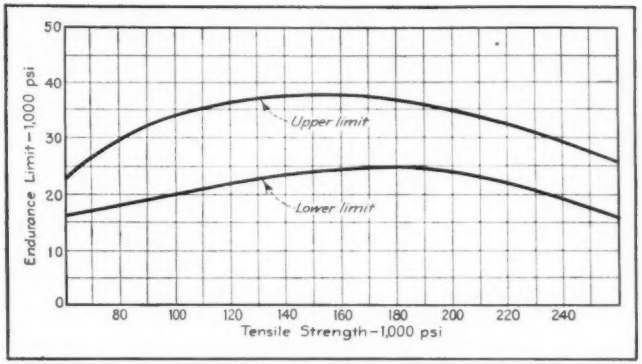

Fig. 6—Upper and lower endurance limits of as-forged parts. Fatigue strength depends upon the combined effect of surface decarburization and irregularities.

polished specimens. E. Houdremont and A. Mailander showed a 28 percent reduction from a 0.004 in. deep toolmark of mild specimens of 150,000 psi tensile strength steel. W. N. Thomas reported a decrease in endurance limit of 20 percent with a wide shallow tool mark in specimens of soft steel. Since only a limited amount of data are available under this category, the plot of the endurance limit versus tensile strength necessitated an extrapolation of the curve for the high-strength steels.

The hot rolled class is included to cover surface conditions encountered on hot rolled parts that have slight surface irregularities, some included oxide and scale defects, with partial surface decarburization. G. A. Hankins and M. L. Becker, and M. L. Becker and G. E. Philips report that the range of stress was 55 percent less for spring steel plates (455 BHN) with a hot rolled surface than for those with a machined and polished surface.

The as-forged category includes parts with large surface irregularities, included oxide, scale defects, with total surface decarburization. Experimental evidence indicates that the low fatigue strength of as-forged parts results from the combined effect of surface decarburization and surface irregularities. The more severe these characteristics are, the lower is the fatigue strength.

Controlled forging operations produce a small amount of decarburization and correspondingly smaller differences between the surface and interior hardness. They are also characterized by less pronounced surface pits and fewer inclusions and surface irregularities. Standard large scale manufacturing processes produce a more pronounced decarb layer and more surface defects. As a result, the endurance limits of large scale manufactured forgings is appreciably lower than the endurance limits of forgings produced under more favorable conditions; some comparative data are shown in Fig. 6. For the purpose of conservative design, Fig. 5 shows the lower of the two sets of values.

Since significant strength is influenced by the surface condition each of the four categories of surface finish can be represented by a separate diagram similar to Fig. 3. As a matter of convenience these four diagrams can be combined as shown in Fig. 7. These four allowable stress lines converge toward the common ultimate strength. At zero mean stress, they intersect the ordinate at values corresponding to the endurance limit for each of the surfaces.

Effect of Hardness

Of all the mechanical properties characterizing steel, hardness is the most significant to the designer from the standpoint of strength. Hardness defines satisfactorily all the other significant mechanical properties of a steel member, is easily measured, and is used extensively to control mechanical properties of the material during fabrication.

For static loading, the relationship between hardness and strength, Fig. 8 is represented by a band, which includes test data on alloy and plain carbon steels. For a given hardness the tensile strength will be essentially the same, independent of the composition of the steel and its processing. Fig. 9 shows the corresponding relationship for the yield point.

In fluctuating loading, the relationship between hardness and strength

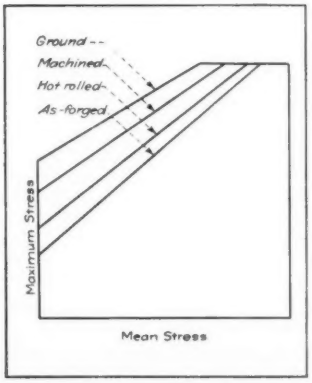

Fig. 7—Significant strength diagram in which is incorporated the effect of the four categories of surface finish.

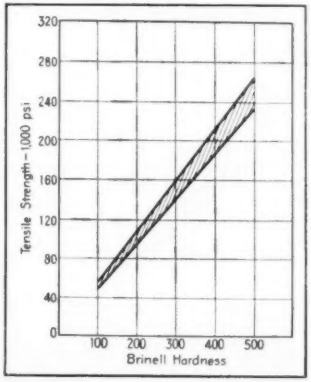

Fig. 8—Relationship between hardness and tensile strength in static loading for alloy and plain carbon steels.

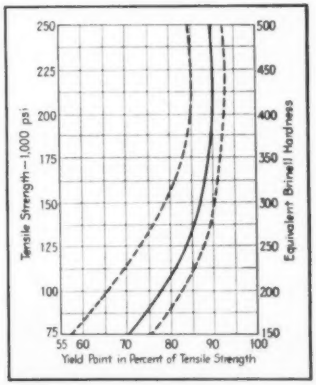

Fig. 9—Relationship between tensile strength and yield point in static loading for alloy and plain carbon steels.

depends on the quality of the surface, as shown in Fig. 10. These curves are derived from Figs. 5 and 8 where, for the purpose of conservative design, lower values of tensile strength were used.

The relationship between hardness and strength shown in Fig. 10 is generally applicable to common steels ranging in hardness from 150 to 500 BHN. In plain carbon steels drastically quenched to obtain hardnesses in excess of 500 BHN, the relationship is no longer valid, because of the detrimental residual stresses associated with drastic quench. In alloy steels, however, the relationship is maintained because the higher hardnesses can be obtained without drastic quenching. Steels in the hardness range of 100 to 150 BHN are used for structural purposes, but their strength is more a function of the fabrication methods than of their mechanical properties.

Table I—Hardness and Strength Properties of Plain Carbon and Alloy Steels

Brinell Hardness	Tensile Strength, psi	Yield Point, psi	Endurance Limit, psi			
			Ground Surface	Machined Surface	Hot Rolled Surface	As-Forged Surface
160–187	77,000	48,000	33,000	30,000	24,000	18,000
187–207	89,000	60,000	39,000	34,000	25,000	19,000
207–217	99,000	69,000	44,000	37,000	27,000	20,000
217–229	103,000	74,000	46,000	38,000	27,000	20,000
229–241	109,000	80,000	49,000	40,000	28,000	20,000
241–255	114,000	86,000	51,000	42,000	29,000	21,000
255–269	121,000	94,000	55,000	44,000	30,000	21,000
269–285	127,000	101,000	57,000	46,000	30,000	22,000
285–302	135,000	110,000	61,000	49,000	31,000	22,000
302–321	142,000	120,000	64,000	51,000	32,000	23,000
321–352	151,000	130,000	68,000	53,000	33,000	23,000
352–375	166,000	147,000	74,000	57,000	34,000	24,000
375–401	176,000	158,000	78,000	59,000	35,000	25,000
401–429	188,000	171,000	82,000	62,000	35,000	24,000
429–461	202,000	183,000	86,000	64,000	35,000	24,000
461–495	217,000	196,000	88,000	65,000	34,000	22,000
495–514	233,000	210,000	89,000	66,000	32,000	20,000
514–555	241,000	217,000	89,000	65,000	31,000	19,000

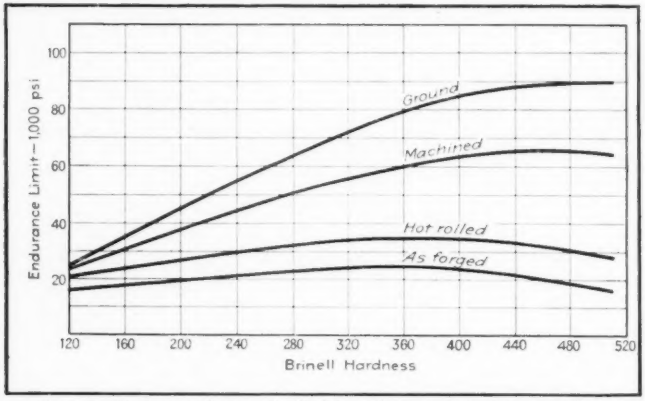

Fig. 10—Hardness and strength of plain carbon steels in fatigue loading.

With the aid of the data given in Table I, diagrams similar to Fig. 7 can be constructed to cover the entire range of tensile strength associated with hardness between 150 and 550 BHN. The classification represents hardness ranges conventionally specified in the processing of steel members. To be on the conservative side, the lower limits of each of the hardness ranges should be used to determine the pertinent tensile strength, yield point and endurance limit.

EDITOR'S NOTE: Part II of this article will discuss the effects of the surface treatment processes on the strength of materials, and the relationship between fatigue strength and life expectancy in service.

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Velocity Distribution in Pump Casings

From "Velocity Distribution in Roto-Dynamic Pump Casings" by Herbert Addison and Ramadan Sadek, *The Engineer*, (London), Nov. 5 and Nov. 12, 1948.

WHILE calibrating rotary water meters some years ago, one of the authors observed that helical type of inferential meter, mounted close to the outlet flange of a screw pump, appeared to be influenced quite unmistakably by some kind of flow disturbance within the pump casing itself. The effect can be seen from the diagram, Fig. 1. At high rates of flow, the meter behaved normally, but at low rates of flow it began to show a positive error: it registered more water than actually passed through it (Curve I). When the discharge valve was fully closed and flow through the pump finally ceased, the pointer of the meter still continued to rotate very slowly, at a rate equivalent to a discharge of about 0.2 liter per second. In an attempt to remedy this serious fault, perforated baffles were fixed in the delivery pipe just above the pump outlet flange. The meter's indications were thence acceptable at all but the lowest rates of discharge (Fig. 1, curve II).

More recent investigations, corresponding tests on a different type of pump, not only cleared up the problem of the meter behaviour, but threw further light on flow conditions within the pump casings. In all the experiments, the basic plan was to establish a suitable transverse plane in or near the pump outlet flange, to choose a number of representative points in this plane, and then at each of those points to try to measure the magnitude and direction of the water velocity. The measurements were made at constant pump speed, and at various flow rates, in the hope of finding out how the rate of discharge influenced the velocity distribution. The instrument used was the Pitot cylinder, an adaptation of the Pitot tube which permits velocity components in two directions mutually at right angles to be closely estimated. While it is true that no information could be gained about the third velocity component, the experimenters believed that this omission would hardly invalidate the trend of the results.

Performance of Screw Pump—A diagrammatic outside view of this pump has been given in Fig. 1, and internal construction is shown in Fig. 2. Although the fourbladed rotor is nominally of the mixed-flow type, it is in fact more akin to the axial-flow or propeller type rotor than to the radial-flow centrifugal pump impeller. At the design point or point of maximum efficiency of the pump, its characteristics were:

Speed, rpm	1,200
Discharge, liters per sec	30.5
Effective head meters	2.95
True specific speed, metric units	340

The pump speed was held steady at 1200 rpm throughout the whole series of tests. The rate of discharge, regulated as desired by the outlet throttle valve, was expressed as a percentage of the normal discharge; thus, as a percentage of 30.5 liters per second.

The most convenient measuring plane lay within the reducing piece, just above the pump delivery flange. The measuring points lay along the two diameters I-I and II-II, respectively perpendicular and parallel to the pump shaft, shown in Fig. 2. In order to present in the most graphic form the information collected by the Pitot cylinder, three-dimensional models were built to scale of wood and wire, and afterwards photographed.

What at once strikes the eye in looking at the models is the helical or

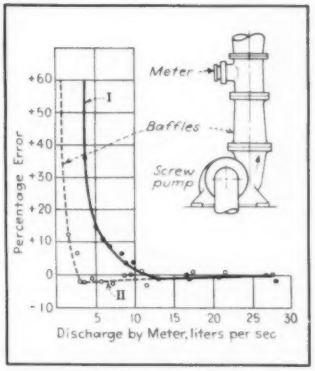


Fig. 1—Meter mounted above pump.

"spin" motion of the water as it leaves the pump. The next point is that the direction of spin progressively changes as the rate of discharge rises. Whereas at the lowest flow rate, 31.2 percent, the whirl is in a counter-clockwise direction as seen from above, yet at the highest flow rate, 117 percent, there is a clockwise whirl. The change-over, or stage of zero whirl, seems to occur at a percentage discharge of about 88 percent. In regard to the longitudinal or vertical velocity components—those along the main direction of flow in the outlet passage—the average values naturally rise with the increase in pump discharge. But the distribution of these components hardly conforms

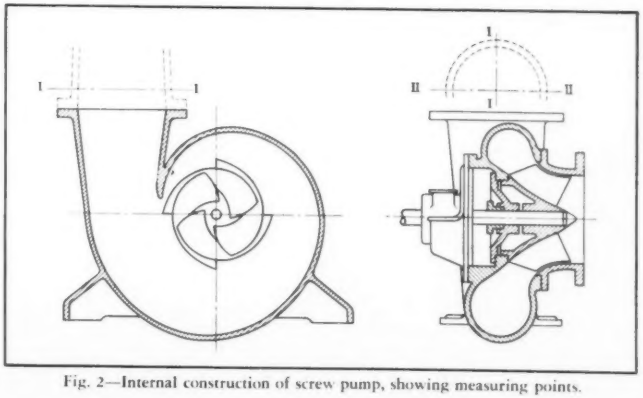


Fig. 2—Internal construction of screw pump, showing measuring points.

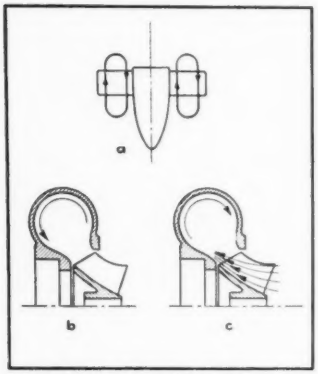


Fig. 3—Explanation of "spin" in volute.

to any clear system. At low rates of flow there is a tendency for the velocity components to have their lowest values near the pipe axis; but there is no sign of a velocity gradient between one side of the passage and the other.

The normal direction of rotation of the water-meter rotor, at low rates of flow, is the same as the direction of spin of the water leaving the pump volute. The spin is so relatively powerful that the fixed guides or honeycomb in the meter casing are ineffective in suppressing it; hence the meter rotor is carried round faster than it ought to be. Even the perforated baffles, could not wholly screen the rotor from this rotary motion.

What was the original cause of the spin? Flow conditions within the pump rotor can be deduced from the study of simpler types of rotor at low rates of discharge. In an axial-flow or propeller pump, for instance, the power input rises as the discharge decreases, reaching a maximum at the point of closed throttle or zero discharge. The usual explanation of this behavior is that low discharge rates are accompanied by an abnormal distribution of axial velocity components within the rotor passages; near the rotor rim these components are greater than they are near the hub or boss. In consequence, a secondary circulation is set up, imposed upon the main flow, of some such nature as is sketched in Fig. 3 (a).

Conditions will thus be favorable to the generation of a secondary spiral flow in the volute of the pump, Fig. 3 (b); and the direction of rotation tallies with the direction revealed by the Pitot cylinder.

The same line of reasoning—which depends upon the differential influence of discharge rate upon the velocity diagrams at the outer and the inner zones of the rotor—suggests that the spin component within the pump volute will gradually be extinguished as the discharge increases, and will then build up again in the reverse direction. The neutral point, or stage of zero spin velocity, occurs before the design point on the pump characteristic is reached; a possible explanation is suggested in Fig. 3 (c). In these conditions of high discharge, the asymmetrical setting of the volute, in relation to the rotor outlet, may itself encourage a clockwise spin. The term "spin" is preferred to the term "whirl," for the sake of distinguishing between two types of tangential velocity component. While the water is within the rotor, it rotates with respect to the pump shaft, and the corresponding tangential component is conventionally termed the "whirl" component. Within the volute, on the other hand, it now appears that the axis of rotation of the water is perpendicular to the pump shaft. To denote this tangential component the term "spin" is used.

Performance of a Centrifugal Pump —When the Pitot cylinder was applied to a centrifugal pump, it revealed a velocity distribution pattern of a different type from what was found in the screw pump. The centrifugal pump was a standard side-inlet machine having branches of 4 in. (nominal) diameter, giving the following performance at its design point:

Speed (constant), rpm	1,215
Discharge, liters per second	20.0
Effective head, meters	5.22
True specific speed, metric units	182

The proportions of the volute are shown in Fig. 4 which also indicates the transverse planes chosen for exploration with the Pitot cylinder. The upper plane was located in the taper piece bolted to the pump outlet flange; here velocity traverses were taken along the diameters I-I and II-II, as in the screw pump. In the lower measuring plane, situated near the volute tongue, velocity traverses could be made along five parallel lines, III, IV, V, VI and VII, each one parallel with the pump shaft. As before, observations were made at various rates of discharge, which are stated in the diagrams as a percentage of the "design" discharge.

The "stereographic" system of velocity representation was as useful for the centrifugal pump as it was for the screw pump. Two significant points are: (1) "Spin" velocity components are of trivial magnitude or are absent altogether; (2) for a given pump discharge there may be a great variation in the vertical velocity components. In the extreme case corresponding to a percentage discharge of 140 percent, the individual vertical components range from 0.5 meters per second at the point of the traverse nearest to the pump shaft, to nearly 6 meters per second at the most distant point.

For showing what was found at the lower measuring plane, an alternative system of presentation was tried. For each of the five traverses, vertical velocity components were set off to scale on sheets of cardboard, and the resulting assemblies photographed. As negative velocities as well as positive velocities had to be recorded, a line of zero velocity was marked on each model. Examine now the general trend

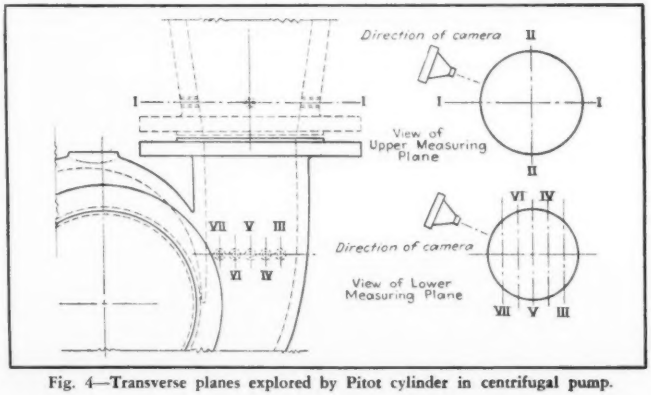


Fig. 4—Transverse planes explored by Pitot cylinder in centrifugal pump.

of the velocity distributions, there is observed a rather surprising uniformity so long as the pump discharge is below the designed value. Thereafter, important variations take place, especially at the measuring point nearest to the pump impeller. As the relative pump discharge rises from 100 to 120 percent and then to 140 percent, the velocity falls from 3.4 meters per second to 2.1 meters per second, and finally to 0.2 meters per second.

As a final summary of available information relating to extreme conditions, corresponding to a percentage discharge of 140 percent, the flow picture reproduced in Fig. 5 is presented. It shows deduced or measured velocity components at three different regions in a vertical diametral plane of the pump outlet passage. Beginning at the volute tongue, there are first to be seen the vectors A, A, representing the absolute velocity direction of the water leaving the impeller; these are deduced from velocity triangles based on the measured pump performance. Next we advance to the lower measuring plane in the outlet passage, here denoted by a a. The vectors plotted here show resultant velocities in the chosen plane—they take account of the velocity direction as indicated by the Pitot cylinder. At the third or uppermost region, at the upper measuring plane, the resultant velocity at the point P is indicated by a vector based on the Pitot cylinder traverse along diameter II-II.

A plausible pattern of flow lines which will fit the framework of vectors already established has been sketched in Fig. 5. The prime cause of the whole complicated flow system is the distortion of the rotor outlet velocity diagram at abnormally high flow rates. Because in these conditions there is an abnormally high angle between the absolute outlet velocity vector and the tangent to the impeller rim, the water cuts sharply across the volute tongue and thereby loses all chance of a tranquil journey to the pump outlet. Thus, the resulting disturbances will be accompanied by serious energy losses. Another kind of evidence, points to excessive energy loss at this stage of the pump's characteristic; at a percentage discharge of 140 percent the pump efficiency is 50 percent as against 77 percent at its design value. An important portion of the corresponding energy loss can be attributed to the eddy at the volute tongue. The conventional method of estimation of the total energy received by the liquid while flowing from the suction to the delivery flange of the pump is based on: (1) Pressure measurements at inlet and outlet flanges, (2) estimates

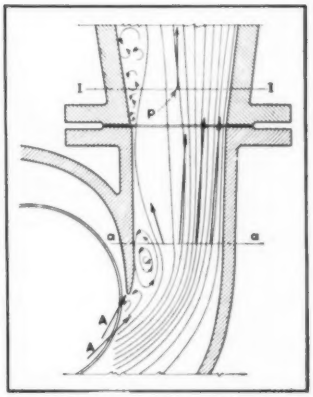


Fig. 5—Flow pattern in centrifugal pump casing shows three velocity components.

of mean velocity at flanges, deduced from measured pump discharge. The underlying assumption is that at each flange the velocity vectors are uniform over the whole area, and are all perpendicular to the plane of the respective flange, parallel to the general direction of flow. There is little justification for this assumption. The figure that purports to represent energy received by the liquid will be an underestimate.

A Self-Locking Thread for Studs

From, "A New Locking Thread Stud" by C. W. Baker, Manager of Technical Sales, National Screw & Mfg. Co. *Fasteners*, Vol 5, No. 2.

THREADED STUDS sometimes work loose in service, and other times are loosened by the torque applied with a wrench when attempting to remove mating nuts. Various schemes have been used to prevent such occurences, one of which is the use of a tapered locking thread known as the Dardelet thread.

Briefly, this thread, shown at *B* in Fig. 1, consists of small sections of conventional thread and larger sections of modified thread having a continuous taper at the root. The small section of conventional thread allows the stud to be screwed into the forging, casting, or machine member, while the tapered roots of the other sections take the stresses when the stud is in position.

Unfortunately, the Dardelet thread is often difficult to use since it requires that a hole be tapped to accurate dimensions at the same time the threading is being done. To overcome this difficulty, a modified and simplified thread called the "Lok-thred" has been developed. The "Lok-thred" takes advantage of the fact that if one or two threads of a bolt can be engaged in a nut, the nut can be secured on the bolt thread even though gaging shows interferences. The fastener deforms the thread to conform to its contour, and this causes a locking action between the mating members.

The form of this thread, superimposed on an American National form, which is indicated by the dotted lines, is shown in Fig. 2. The interference at the root causes the metal to flow into an intimate fit with the tapered section of the thread. Voids are deliberately left at the flanks of the thread, and these are filled with the displaced material. Thus, the thrust is taken on the 6 deg tapered root, which holds the stud in place.

The only special preparation necessary for the use of this thread is the drilling of a hole to dimensions recommended by the manufacturer and tapping this hole with an American National Class 2 or 3 thread tap. The hole size will vary with the hardness

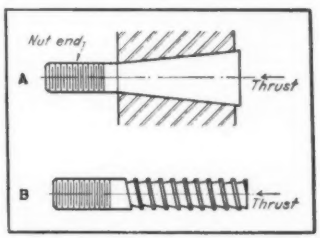


Fig. 1—When thrust is applied to the stud shown at *A*, it becomes locked in place. This principle is utilized in the Dardelet thread, shown at *B*, by adding a continuous taper to the root of a modified thread and using only a small section of standard thread.

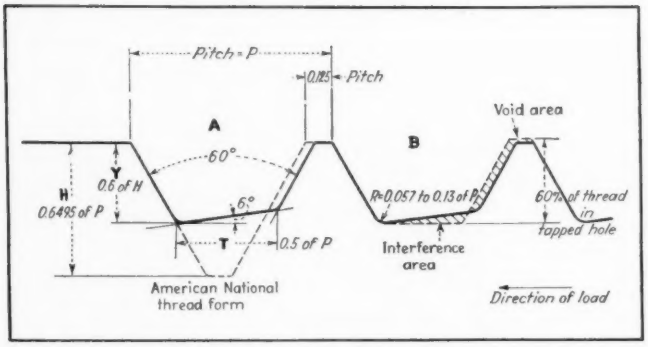


Fig. 2—The new "Lok-thred" is based on the principle that a nut can be screwed on a bolt even if there is interference in the threads, since the threads will deform and lock the assembly in place providing they are tapered. The heavy black line at *A* shows the form of the bolt locking thread, while the dotted line shows the corresponding American National Thread form. Position *B* shows the action which occurs when the male locking thread enters the tapped hole.

of the parent material and the approximate torque necessary.

Besides its positive locking action, one other advantage of the thread is that it seals the hole. In one test case, 7/16 in. studs were driven into a cast iron test block using kerosene as a test medium, and pressures were gradually increased up to 3,000 psi without leakage. During a similar test on an aluminum test block the pressure exceeded 1,500 psi, but at that point leakage was encountered through the porous material of the test block itself. Reports from tests made in the field have indicated applications in which pressures greatly exceeded this range; in one instance a stud was subjected to pressures of 10,000 psi before any leakage was encountered. It is possible to make many different modifications on this thread to improve adaptation for certain applications. To facilitate the driving of the thread, a short section of lead thread is added to insure easy entry into the tapped hole. There are other ways of securing this result, but this is normally the best practice.

For stud usage, a tapered stud dia of approximately 0.003 in. per in. of thread is used, the particular advantage of this design being that studs that are removed, can be reinstalled and tightened to the original holding force with about a $\frac{1}{8}$ additional turn. On cap screw or bolt applications, this taper is omitted since the nut normally does not advance beyond the original point and so is unnecessary.

The thread has been driven successfully into various types of material including aluminum, magnesium, steel and cast iron. Fasteners incorporating the design have been produced in low carbon, high carbon and alloy steel. It is a basic principle that the surfaces of the male member must be harder than the material into which the part is being assembled, and must be sufficiently hard to reform the metal of the socket thread. This is done by various means; sometimes the piece is cyanide hardened, and at the other extreme, alloy steels are carburized for surface hardness and then drawn back to obtain the desired core hardness.

The torque required to install the stud is not excessive and compares favorably with the torques normally specified for lock nuts. The removal, or break-loose torque is high, probably exceeding the torque required to remove most lock nuts. If anything, this removal torque increases in service. When bolts of this design have been subjected to working loads for long periods, the threads seat themselves with even more of a wedging action along the 6 deg taper.

These studs are available in sizes from No. 6 machine screw size to the larger diameters of bolts, cap screws, and studs, and are being used successfully in the manufacture of motor cars and trucks, agricultural implements, washing machines, and a wide variety of other products.

One manufacturer is using a modified stud having a large number of conventional threads and only two or three threads of this new design to provide tightness and lockup the assembly.

Designing with Fabricated Plastics

From "Industrial Designer's Viewpoint of Fabricating Potentials" by H. F. Pearson, Pearson-Berlinghof, Inc., presented at the annual meeting of the Society of the Plastics Industry, May 21, 1948, Atlantic City, N. J.

IN THE COMPLEX PLASTICS FIELD there is no definite line between molders and fabricators, except in quantity and method of production. As molding techniques advance fabricators will do small quantity molding.

A large proportion of fabrication is for display. The requirements of this field permit the specialized properties of plastics to be used. Gradually finding out what plastics can do from these uses, people will begin to accept them.

Sometimes this field comes close to molding quantities, as in advertising signs. However, a fabricator set up to do quantity production, perhaps even using molding techniques modified to his capacity, can offer close competition to the molder.

The designer who knows plastics is at an advantage. For example, the acrylics have endless possibilities for special effects. Acrylics, polystyrene and other transparent plastics can be made either almost invisible when their purpose is to display another material, or rendered brilliantly visible when used to call attention. Forms, decorations, lighting, all take on new aspects with such materials.

An acrylic lamp, designed so it cannot easily be cleaned, begins to look dingy after a few months of normal usage. The static charge of acrylics collect dirt. The designer thus must design in such a manner that surfaces which cannot be cleaned are protected. The problem is a direct challenge to the materials manufacturer; perhaps he could develop a clear antistatic varnish that would, at the same time "solvent polish" machined surfaces.

The greatest potential of fabricated plastics is in making bases, cases, handles and industrial parts. What portion of this falls to fabricators depends on the quantity needed.

A tendency that will grow is to have fabrication of parts done by the company making the entire product. Radio dials can more economically be done by the radio company; advertising companies make their own signs, whether of wood or plastic; refrigerator companies find that they can fabricate their own handles.

Television Set Reflects Images On Huge Screen

TELE-VIDEO, a reflection-projector television system, is capable of projecting life-size pictures on a screen as large as 7 by 9 ft. Images from a 5-in. kinescope picture tube are reflected from a 14 in. mirror onto a special wide-angle viewing screen that provides sharp picture reproduction in a normally lighted room.

The familiar all-inclusive cabinet television receiver has been replaced with a 4-unit remote control system that permits flexibility of installation and ease of servicing. Connector cables 50 ft. or more in length make it possible to select channels and focus the image from the rear of a large auditorium containing several hundred people.

Design-wise, the greatest departure from current practice is the optical barrel assembly used in the Tele-Video receiver. Based on the Schmidt optical system, image projection from the 5-in. kinescope is via a silvered mirror of 14-in. diameter. A corrector lens of 9⅜-in. diameter is mounted around and supports the base of the kinescope. Light output from this system is seven times that obtained with conventional refractive lens systems.

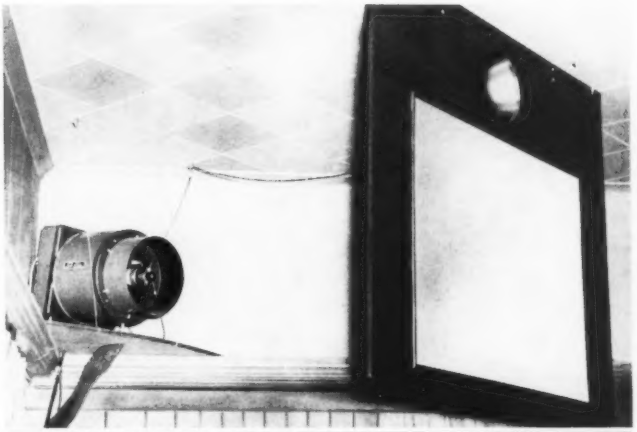
The 30-kilovolt power supply is located behind the mirror and is surrounded by a Plexiglas case. Electrostatic collection of dust is thus prevented and a safety feature provided.

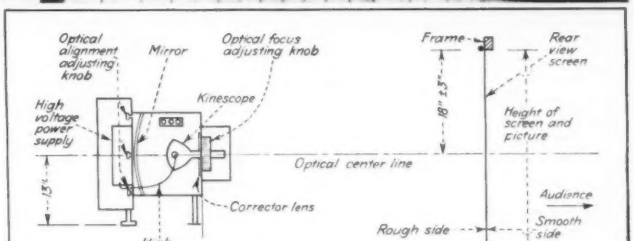
The master control unit with its centralized panel contains all the operating controls required to tune the system. Volume, tone, vertical and horizontal hold, picture brightness and station selection are all controlled from the one panel. An amplified automatic picture gain control circuit is provided in the master unit.

The remote driver unit houses the sweep circuits that convert incoming signals into pictures on the kinescope. A thermostatic delay relay is built into the kinescope high voltage supply to protect the tube.

The audio amplifier unit produces 20 w of sound power. The frequency range extends from 20 to 20,000 cps and distortion at full-power output is 0.5 percent. A 12-in. loudspeaker, usually mounted in the screen assembly, is energized by a 6.8 v Alnico magnet.

Special circuits developed for radar equipment are used in the video amplifier. A band pass of over 5 megacycles provides maximum picture resolution and detail. Receivers are manufactured by the Tele-Video Corp. of Upper Darby, Pa. and marketed by the Telecoin Corp. of New York City.





OPTICAL BARREL and screen assembly as mounted to produce 3- and 4-foot picture. No adjustments are needed to align optical system if optimum range is maintained.

G-E Completes New Low Temperature Laboratory

TEMPERATURES of 459 deg below zero Fahrenheit will be commonplace in a new $250,000 low-temperature laboratory just completed by the General Electric Research Laboratory at Knolls, near Schenectady, New York.

The building is 60 by 70 ft overall. Half of the space is taken up by two huge liquefying plants, where liquid helium and hydrogen will be made for use in experiments. The plant is expected to produce about seven gallons of liquid hydrogen and two gallons of liquid helium in an hour. The remainder of the building is given over to laboratories for experiments, large electric generators to run electromagnets for magnetic studies at low temperatures, and a machine shop for maintenance work on the liquefiers.

Liquid helium and hydrogen will be produced because of their extremely low liquefaction temperatures, which are 4.2 and 20.3 C above absolute zero. The liquefiers make use of the so-called "regenerative Joule Thompson cycle." The gases are compressed, then fed

through coils to cool, passed through a chamber cooled by liquid nitrogen (for hydrogen) or liquid hydrogen (for helium), then expanded violently by being sprayed from a nozzle. Only about 20 percent of the gases liquefy at the nozzle, the remainder being used to cool down gases on their way to the nozzle.

The extremely cold liquids are kept in vacuum-insulated tanks, resembling the common thermos bottle. The entire liquefier circuits are enclosed in vacuum-insulated jackets. The hydrogen liquefier will operate at a pressure of 2,400 psi; the helium liquifier at 400 pounds per square inch.

In describing the new laboratory, Dr. Milan Fiske of the G-E staff cited examples of the phenomena that occur near absolute zero. Liquid helium below 2.19 deg absolute becomes superfluid—its viscosity vanishes. If it were to be set in motion like stirred coffee spinning in a cup, it would theoretically continue to spin forever.

Fiberglas Used As Series Cutout in D-C Lamps

FIBERGLAS CLOTH is replacing the lava spacer and oxidized aluminum wires of Westinghouse gas-filled lamps used on a New York subway where twenty lamps are operated in series on a 600 v d-c circuit.

When the filament in any of the twenty lamps fails, the series circuit is momentarily broken and a potential of 600 v is impressed across the lead-in wires of the failed lamp. An immediate insulation breakdown occurs through the interstices of the Fiberglas, the gas acting as a conductor. The result is a fusing together of the wires to maintain the series circuit. The cutout will operate at 200 v when sealed in the lamp, at 500 v when in the open air.

Porcelain-Enameled Bearings Gaining Popularity

AT LEAST ONE COMPANY now manufactures a complete line of porcelain enameled steel bearings for the food and chemical industries—corrosion-resistant bearings designed to operate in almost all liquids.

During the war, this type of bearing was thoroughly and successfully tested in boats, pumps and chemical tanks, and has proved satisfactory in irrigation, air conditioning, hydropneumatic and other installations in general industry. Field tests over a period of six years indicate that they will out-wear common rubber bearings and monel sleeves about five to one, and oil lubricated bearings about 25 to one.

The bearings are made of steel tubing completely covered with a special extra-hard, acid-resistant porcelain enamel. A self-lubricating, revolving synthetic rubber journal fits over the shaft and rides against the porcelain enamel-protected bearing surface. The wet rubber journal slides over the enamel with a minimum of wearing friction and the bearing lubricates itself with the liquid in which it operates.

One manufacturer used the porcelain enameled bearings 24 hours a day during the war years for pumping oil with a high sulphur base. The bearings are still like new. A deep-well turbine pump equipped with these bearings had been running for 59 months when last reported and the bearings showed only 0.005 in. wear. When tested against a standard automobile water-circulating pump bearing, the enameled bearing operated for 500 hours at 75 mph before failure. The standard model burned up in 30 minutes under the same conditions.

The synthetic rubber journal mentioned above is molded in sections $\frac{3}{4}$ in. high and approximately $\frac{1}{4}$ in. thick. Sections can be stacked to give any desired length, according to horsepower requirements. The hole in the journal is smaller than the shaft and, when forced over the shaft, the journal is sufficiently tight to revolve with it. The tubular walls of the bearing are approximately $\frac{1}{4}$ in. thick and are turned smooth to fit into a spider.

Liquid Hydrogen Motor Developed for Rockets

THE HYDROGEN that carries balloons to great heights may some day take rockets into the outer space beyond the pull of gravity. But it will be liquid hydrogen, and the rocket will carry liquid oxygen to permit combustion. The liquid hydrogen is the fuel; liquid oxygen the oxidizing agent.

A rocket motor utilizing these elements has been in experimental use at the Ohio State University for over a year. This test motor, no larger than a human hand, produces a thrust higher than that developed by the engine of the average small airplane. Its exhaust jet nozzle emits gases at a speed of 15,000 miles per hour.

"Cost Reduction" To Be Theme of the June P.E.

MORE THAN 80 PAGES in the June issue of PRODUCT ENGINEERING will be devoted to product designs in which special fabrication processes, materials changes and components simplification have resulted in appreciable savings in production and materials costs.

Two examples of the more than 200 subjects: a freight car journal-box made from a single 1040 steel forging that is bent to shape and welded at the top; and a domestic fan with only four major parts—one, the driving motor; and the other three, the main housing, the filter bracket and the bladed rotor, all three molded of plastics.

All-Weather Blades Use Laminated Plastic

THE GROWING USE of plastics in aircraft structural applications is typified by application of this material in the new all-weather helicopter blades built by Goodyear Aircraft Corp. and installed on a Sikorsky R-5 for testing.

Leading edge of the rotary wing is 0.030 in. stretched stainless steel. There are no seams or splices, and support is via two spanwise spars spotwelded to the skin. Leading edge rigidity and static balance are afforded by a strip spotwelded to the blade's inside curve.

Behind the main spar is a 0.007 in. core of laminated phenolic plastic, sandwiched between 0.0015 in., type 302, $\frac{1}{4}$-hard stainless steel sheets. This skin covers the ribs that form the contour of the aft two-thirds of the blade section. It offers the advantages of affording practically the same rate of thermal expansion as the leading edge stainless steel section combined with maximum stiffness and maximum weather resistance.

Washington Notes

Success of X-1 Dispels Fears of Supersonic Speeds

Some aeronautical engineers believe that one of the most important results of flights made by the supersonic Bell X-1 rocket plane was the change it made in the thinking of aircraft designers.

"The successful flights of the X-1 caused a 'psychological revolution' among designers," according to Dr. Hugh L. Dryden, director of aeronautical research for the National Advisory Committee for Aeronautics.

"For years it had been supposed that aircraft could not penetrate beyond a 'sonic barrier'. Early experience with the forces encountered as the speed was increased led to the picture of a transonic region as a region to be avoided or hurriedly traversed. The flight of the Bell X-1 to supersonic speeds has modified that concept."

The X-1 is of conventional design with the exception of a new type tail and the greater strength built into the entire structure. Although the original X-1 was designed for a top speed of 1,700 mph at 80,000 ft, it was not capable of that speed when it took to the air. The reason was that a turbo-pump to force liquid oxygen and alcohol-water into the four rocket burners had not been designed. An interim system that used nitrogen under pressure to force the fuels into the burners cut down the fuel capacity from 4 to 2½ min. at full power.

Another model of the X-1, equipped with the turbo-pump, is being built. Engineers believe it will be able to meet the performance level set for the original X-1. How soon this plane will be ready has not been disclosed.

There are many misconceptions about the X-1. It is a "practical" airplane, but not a tactically useful plane. Its aerodynamic design is not regarded as optimum for supersonic speeds, as it was built to verify results obtained by other methods.

First Delta-Wing Plane Undergoing Flight Tests

THE USAF'S NEWEST RESEARCH AIRCRAFT, designated as the Model 7002 for identification purposes, is undergoing flight tests at Muroc, California, Air Force Base. Designed and built by Consolidated Vultee Aircraft Corp. at San Diego, Calif., the plane features a delta wing, first aircraft of this type.

The radically-designed aircraft is being used to explore and test stability and control characteristics of the delta wing. This type of wing differs from conventional designs in that it has a much larger degree of sweepback—60 deg compared to 35 deg that is the maximum now being used on Air Force aircraft. The wing is triangular-shaped and incorporates elevons in the trailing edge for aileron and elevator action, thus doing away with need for a tail section. A vertical stabilizer and rudder are provided to give added directional control and stability.

Experimentation and evaluation of the aerodynamic characteristics of the delta wing have been carried on in wind tunnels for several years, and these tests have indicated that the wing has low drag characteristics and satisfactory control in transonic and supersonic speed ranges.

The Model 7002 is powered by an Allison J-33 turbo-jet engine rated at 5,200 lb thrust with water injection. It has a tricycle landing gear and a jettisonable bubbletype pilot's canopy.

Army Sets Up Plan for Placement of Scientists

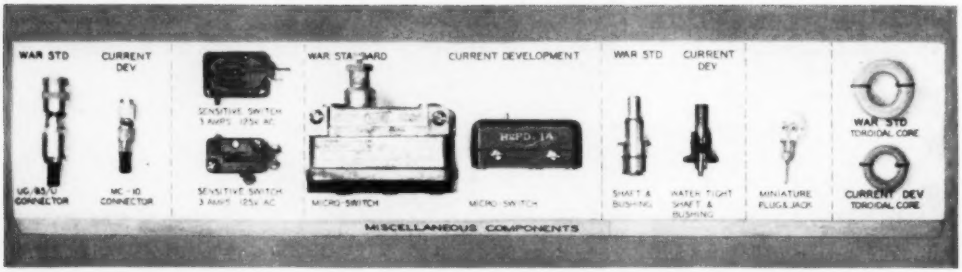
The Army has set up what it thinks may be the procedure for handling the placement of scientists who are drafted in the event of another war.

The procedure is already in effect for scientific students and graduates already drafted. The plan is to pull scientists into a central technical pool or detachment—after completion of basic training—from which they will be assigned to duty where their scientific training and abilities will be best utilized.

The procedure works automatically for draftees who already have their degrees in engineering or the scientific professions. Under-graduates who have completed their junior year (sophomore year for engineers) are screened according to the score they make on the Army General Classification test. Those who possess the required college credits and who get a high enough score in the test are brought to the technical group for further assignment.

Information is being sent to the country's universities in order that they may work out methods of providing transcripts of students' records needed by the Army.

There has been considerable study given by the Army to the admitted mis-use and waste of scientific manpower during World War II. Recently, the Army published a report which documented the complaints of the professional and engineering societies, and the scientists themselves. The report, titled "Scientists in Uniform, World War II", contained figures showing that only 29.6 percent of the scientists and technical men who were in uniform were "well utilized". At the other end of the scale, 23 percent were given routine GI assignments



Signal Corps' all-out "miniaturization" program is evidenced by reduction in dimensions of smallest electrical components.

Signal Corps Stresses "Miniaturization" of Equipment

THE PACK-HORSE ASPECT of Signal Corps soldiering is passing into history, thanks to the ingenuity of science and the persistence of Army research.

Today vest-pocket type signal equipment, candy-bar sized batteries and all manner of portable radar, radio and radiosonde outfits lend a degree of streamlining to communications that was unknown even as late as the end of World War II.

"Miniaturization" is the official description of this Signal Corps program that is designed to fit the task of communications into an Army geared for speed and mobility and in which much of the signal equipment used in the late war is becoming obsolete.

Two main purposes are served in the constant search for smaller, lighter and more efficient signal equipment.

First, the defense needs of the nation require signal equipment that is lighter in weight and can be handled with greater facility by less personnel. It must also be more durable to withstand the rigors of swift mobility and the wide climatic range to which it may be subjected.

Second, and considered more important in the broader aspects of Army planning, is a means of providing greater protection to soldiers under battle conditions, a factor that was not always present in days when signal equipment was cumbersome and conspicuous.

Some of the items already subjected to miniaturization are: A radar set that once required five two-and-a-half ton trucks to transport, reduced to the size of a standard office desk and easily transported in a single truck; midget storage batteries weighing only $5\frac{1}{2}$ oz that can produce enough electrical energy, when used four to a pack, to operate a transmitter up to 100,000 ft above the earth's surface; a complete telephone switchboard weighing only $2\frac{1}{4}$ lb that can replace the Army's standard 60-lb instrument; radio tubes a fraction of an inch in length, and many other units of signal equipment.

---

that made no use whatsoever of their technical training.

Five factors were cited in the Army General Staff Report for the Military's failure to get the most from the available technical talent:

1. Lack of draft procedures designed to single out the scientists.
2. Poor placement of scientists by the organized reserve, to which many scientists belonged.
3. Poor pre-war liaison between the military and the scientists' professional societies.
4. Rigid application of physical standards that were actually irrelevant to the work to which the scientist should have been assigned.
5. Lack of any organized method of assigning scientific talent in the military services themselves.

Titanium Symposium Sponsored by ONR

For the first time, all organizations interested in the engineering exploitation of titanium—producers, military and non-military consumers and research laboratories—met in Washington to discuss the status of work currently underway on this new metal. Sponsored by the Office of Naval Research, the sessions were attended by more than 250 representatives.

The 17 papers presented dealt with programs sponsored by member agencies of National Military Establishment; reports on production and properties of pure titanium; alloy development studies; and the physical metallurgy studies of titanium and its alloys.

The outstanding features of the program, according to ONR scientists, were the advances made in the consolidation of titanium metal, the remarkable corrosion resistance of titanium to salt water and to marine environments, and the progress being made in titanium alloys.

It was pointed out that a major drawback to more widespread applications of titanium is the high price of $3.00-$5.00 per pound. Most techniques now used are for production of titanium by "batch processing" and utilize titanium powder or sponge as the essential raw material. By consolidation of titanium metal is meant the transformation of powder or sponge into a dense ingot of titanium. Conventional powder metallurgy techniques have been used until recently, but they did not lend themselves readily to continuous, cheap, large-scale production. New methods of consolidation were discussed at the symposium, including melting of titanium in graphite or other crucibles, arc-melting of titanium and sheath-rolling of titanium powder. It was estimated that the price could drop to $0.50-$1.00 a pound as the techniques are improved.

A significant report at the symposium was one describing the high resistance of titanium to corrosion in marine environments. Indications are that it stands far ahead of current materials, such as steels, brasses and nickel alloys, in withstanding deterioration in these environments. Titanium was compared to platinum or Hastelloy "C" in its resistance to salt water corrosion. ONR scientists see the first large-scale applications of titanium and its alloys where corrosion resistance is of primary importance.

New Magnetic Materials Discussed at AIEE Meeting

AN ALL-DAY SYMPOSIUM devoted to magnetic theory and new magnetic materials evoked wide interest at the recent Winter Meeting of the American Institute of Electrical Engineers held in New York.

"Recent Advances in Magnetic Theory", was the subject of a paper by R. M. Bozworth, Bell Telephone Laboratories, Inc. The present status of domain theory as applied to crystals and to fine powders as well as ferromagnetic resonants was discussed. This paper, in citing the latest ideas on magnetism, was the keynote to subsequent papers concerned mainly with specific magnetic materials.

Under the joint title of "Materials With Preferred Grain and Domain Orientation" three papers were presented. The first, "Crystal Orientation in Magnetic Alloys," by M. F. Littman, Armco Steel Corporation, cited methods for obtaining crystal orientation and the effect of crystal orientation on permeability. The second paper was "Iron-Silicon Alloys", by G. H. Cole, Armco Steel Corporation. The characteristics of these alloys, hot-rolled, high-silicon sheet, and cold reduced silicon steel strips are widely used in 60-cycle transformers. The last paper in this group was presented by E. A. Gaugler of the Naval Ordnance Laboratories, whose topic was "Iron-Nickel and Other Alloys." These are new materials that possess so-called rectangular hysteresis loop characteristics and are useful in mechanical rectifiers and magnetic amplifiers.

The afternoon session consisted of four papers. The first two were grouped under the heading "Materials for High-Frequency Application." D. C. Dieterly, Armco Steel Corporation, spoke on "Thin Gauge Iron-Silicon Alloys," and Frank Brockman of the Phillips Laboratories, described the properties of Ferrites (Ferroxcubes).

"Magnetic Properties at High Operation Temperatures" was discussed by M. L. Manning of the Kuhlman Electric Company. The advent of silicon insulation, which permits higher operating temperatures for electrical equipment, has made it important for magnetic materials to retain their characteristics at higher operating temperatures. A discussion of these characteristics under high operating temperature conditions was the subject of Manning's paper.

The last paper was presented by A. H. Geisler, General Electric Research Laboratories, who spoke on "Permanent Magnet Materials," describing how these materials are made and criteria for good characteristics.

PRESIDENT OF AIEE for 1949 is James F. Fairman, Vice-President in charge of electrical production at the Consolidated Edison Co., New York City.

Materials Handling Show Stresses Economies

PRODUCTION ECONOMIES gained through efficient handling was the theme at the Third Annual Materials Handling Exposition and technical conference held in Philadelphia under the co-sponsorship of ASME and the Materials Handling Institute.

Interesting designs found at the 200 exhibits were:

A new line of gasoline fork lift trucks that feature fluid drive, automotive controls and a two-stage piston lift. These Lift King trucks represent Yale & Towne's entrance into the gasoline driven truck field.

A magnetic lift truck drive containing two rotating magnet coils, one for forward motion and the other for reverse, mounted within the flywheel of Clark Equipment Co.'s new Dynatork line.

A large lift-transport truck that is capable of lifting a 5-ton load and carrying it along a highway at 30 miles per hour.

A trolley hoist driven by a constant speed motor and fluid coupling.

A hoist featuring a shielded buss-bar-type electrical system that is of simple design and easily serviced.

MEETINGS

April 11-12
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—Conference on Industrial Application of Electron Tubes, Statler Hotel, Buffalo, N. Y.

April 11-13
SOCIETY OF AUTOMOTIVE ENGINEERS—Aeronautic and Air Transport Meeting, and Aircraft Engineering Display, Hotel New Yorker, New York, N. Y.

April 11-13
AMERICAN SOCIETY OF LUBRICATION ENGINEERS—Fourth Annual Convention, Hotel Statler (formerly Pennsylvania), New York, N. Y.

April 11-14
NATIONAL ASSOCIATION OF CORROSION ENGINEERS—Fifth Annual Conference and Exposition, Netherland-Plaza Hotel, Cincinnati, Ohio.

April 11-15
AMERICAN SOCIETY FOR METALS—Western Metal Congress and Exposition, Shrine Civic Auditorium, Los Angeles, Calif.

April 19-20
MAGNESIUM ASSOCIATION—Annual Spring Meeting and Exhibit. Edgewater Beach Hotel, Chicago, Ill.

April 25-29
AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Oil and Gas Power Division Conference, Hotel Sherman, Chicago, Ill.

April 25-29
SOUTHERN MACHINERY AND METALS EXPOSITION—Municipal Auditorium, Atlanta, Ga.

May 2-4
AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Spring Meeting, New London, Conn.

May 19-21
SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS—Spring Meeting, Hotel Statler, Detroit, Mich.

May 26-27
SOCIETY OF THE PLASTICS INDUSTRY—Annual Meeting, Edgewater Beach Hotel, Chicago, Ill.

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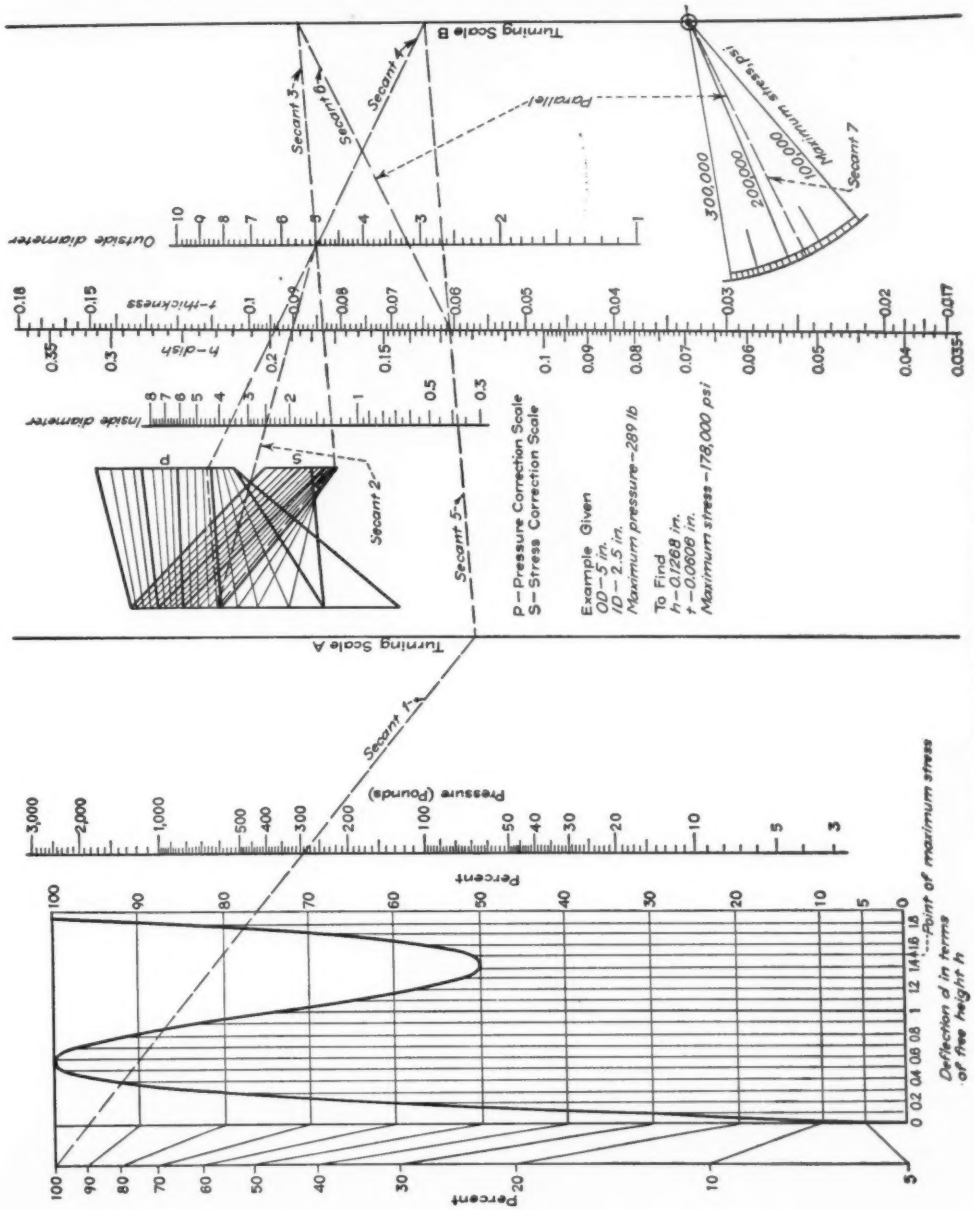
Belleville Spring Design Charts—III

LESLIE W. JONES
Corning Glass Works

For description of chart construction see Product Engineering, January 1949, page 161.



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Belleville Spring Design (continued)

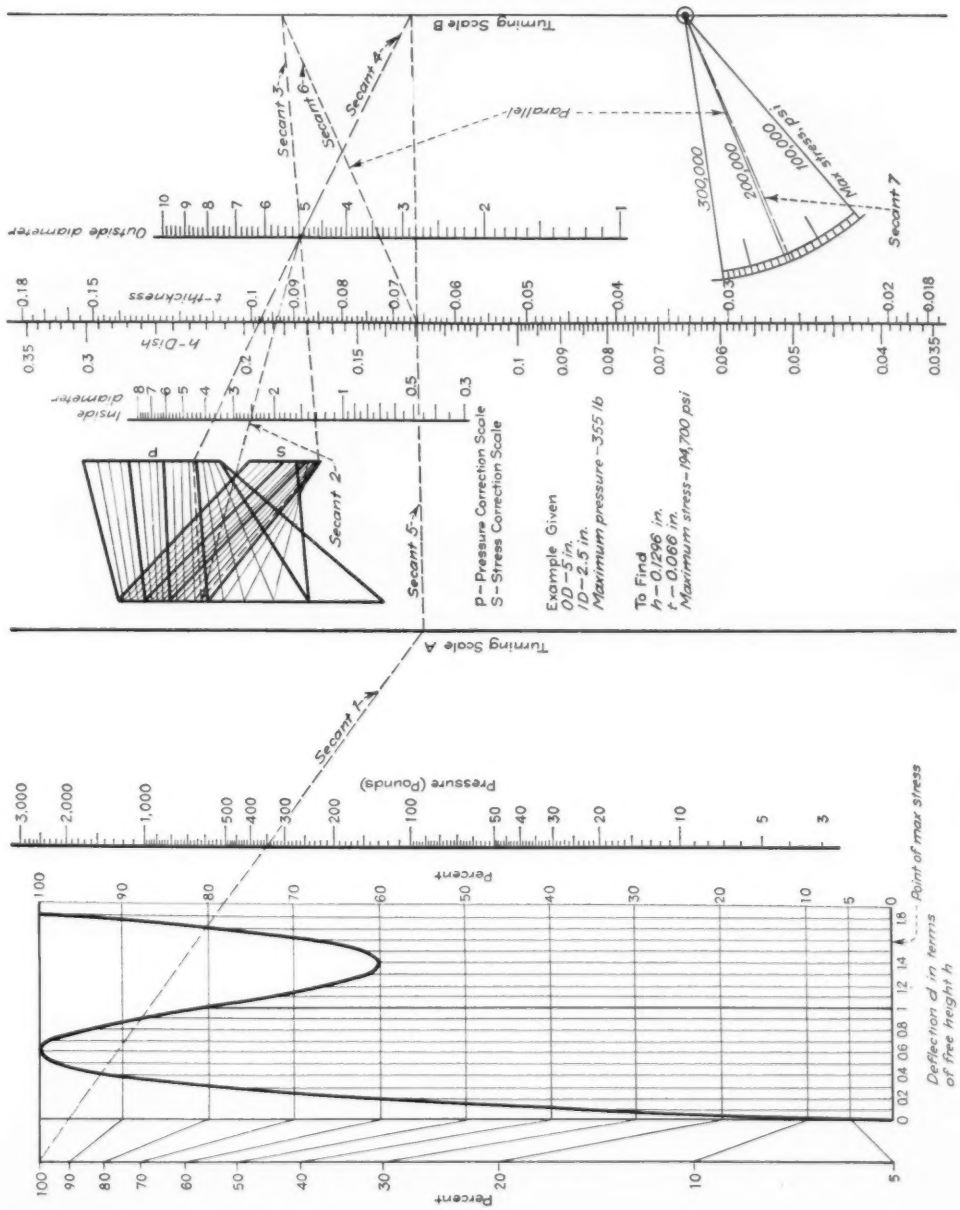


CHART FOR FORTY PERCENT PRESSURE DROP

"TRIPLE-DECKED" RUST PROTECTION

FOR FORMED PRODUCTS

Finished products or equipment made of ARMCO ZINCGRIP-PAINTGRIP last longer in service because they are protected from rust by this three-layer shield: **1.** A unique zinc coating that **can be drawn or formed** without flaking or peeling; **2.** A mill-applied Bonderized finish that **takes** and **preserves** paint; **3.** The paints or enamels you apply after fabricating.

Actual field tests show that the coating on ZINCGRIP has 15% to 45% greater atmospheric corrosion resistance than regular galvanized sheet coatings of equal weights. And because the specially-applied zinc coating s-t-r-e-t-c-h-e-s when drawn, it provides **unbroken** zinc protection for sharply curved sections as well as flat parts.

Next, the ARMCO mill-Bonderized finish known as PAINTGRIP comes into play. This neutral surface film can be painted without chemical etching. By insulating the paint from the zinc it preserves the natural oils in paint, preventing premature flaking or peeling.

FIRST OF ITS KIND

ARMCO ZINCGRIP-PAINTGRIP was the **first** zinc-coated steel that could be severely formed and drawn and painted immediately without pretreatment. It has a record of more than 11 years in proved service.

You may not be able to obtain as much of this special-purpose steel in sheets or coils as you could use now, but we're doing everything we can to meet your needs as **soon** as possible. Armco Steel Corp., 126 Curtis St., Middletown, Ohio. Export: The Armco International Corporation.

ARMCO ZINCGRIP-PAINTGRIP STEEL

ARMCO

Flat Plate Load Curves

TYLER G. HICKS

RAPID DETERMINATION of safe uniform loads for flat steel plates is facilitated by use of the curves shown. These curves are based on the Bach and Grashof formula. For a flat steel plate with all edges fixed the stress formula is,

$$s = \frac{a^2 p}{3.246\, t^2}$$

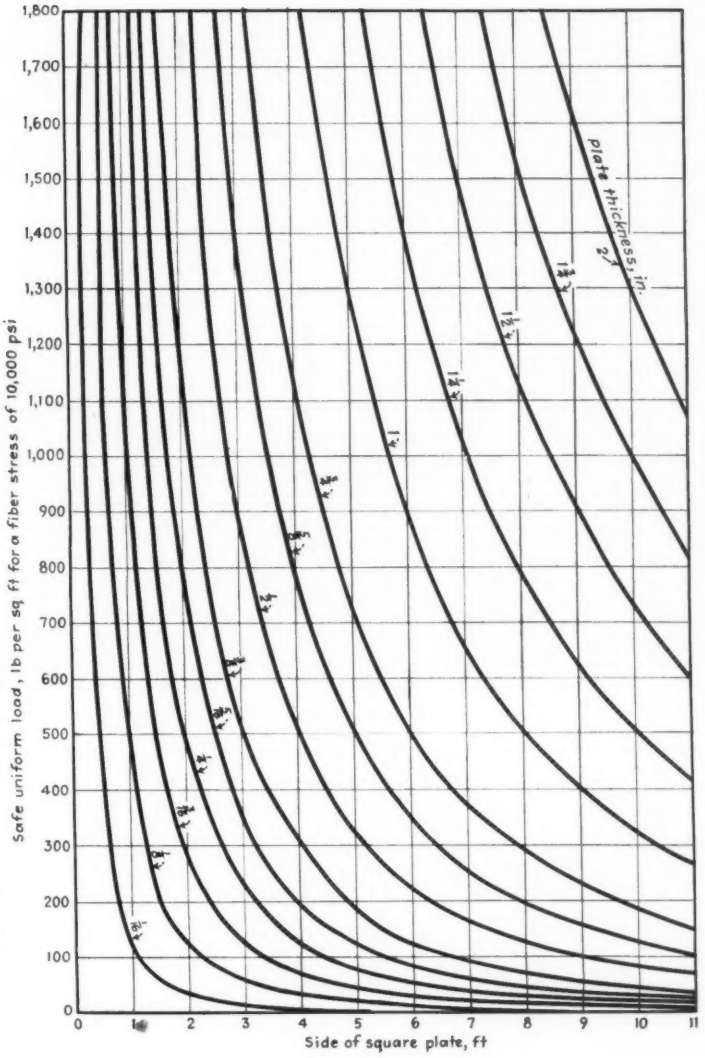
where

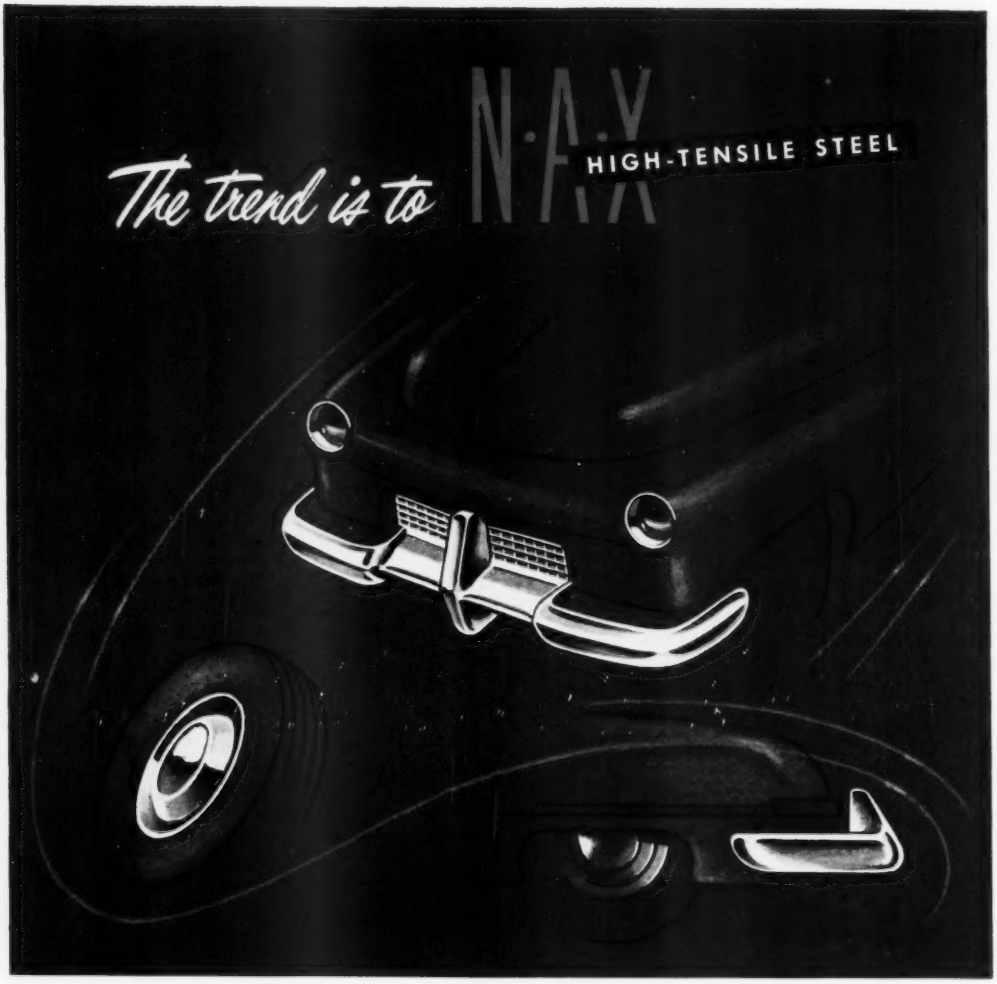
s = unit stress, psi
a = side of square, in.
p = load per unit area, psi
t = plate thickness, in.

The curves are drawn for an assumed fiber stress of 10,000 psi. In designs where a different stress value is used, simply multiply the safe allowable load from the curve by the ratio of fiber stresses. Plates which are bolted or welded around all edges can be considered fixed.

EXAMPLE: Find the safe uniform load for a 1/2 in. steel plate, 4 ft sq.

Solution: Enter the curve at 4 ft on the abscissa, and run up to the curve marked 1/2 in. Opposite the intersection read 507 lb per sq ft on the ordinate.





Since 1940, when Great Lakes Steel pioneered the application of high-tensile, low-alloy steel to cold-stamped automobile bumpers, there has been a growing trend to N-A-X HIGH-TENSILE steel in the automobile industry.

Today, every car manufacturer is using the inherent better properties of N-A-X HIGH-TENSILE steel for some part of his automobile.

Bumpers and grilles—hoods and fenders—body panels and deck lids—frames and bracings—wheels and hub caps represent a few of many applications of N-A-X HIGH-TENSILE steel to the modern car.

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NEW MATERIALS AND PARTS

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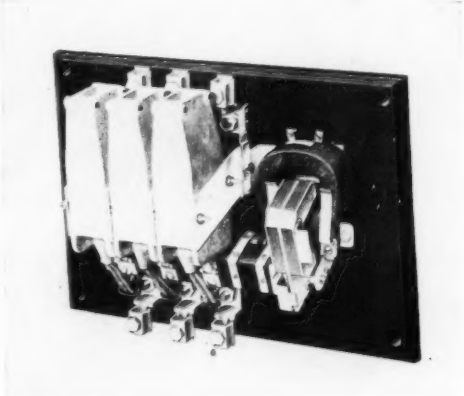


Magnetic Contactors

Ward Leonard Electric Co., Mount Vernon, N. Y.

Sizes 4 and 5 a-c magnetic contactors consist of a laminated iron magnetic frame with a movable armature, an operating coil and set of copper main contacts. These 150 and 300 amp contactors have removable arc shields for all main poles. Movable and stationary contacts on both sizes are identical and interchangeable. Size 4 contactors are available with a maximum of 5 main poles, and size 5 units are made with 2 or 3 poles. Both sizes can be supplied with open type construction or with NEMA Type I inclosures. Coils are obtainable for operation on 110, 208-220, 440 and 550 v on frequencies of 25, 50 or 60 cycles. The maximum inclosed power rating for size 5 contactors is 200 hp, 550 v, 60 cycles.

High Temperature Fasteners

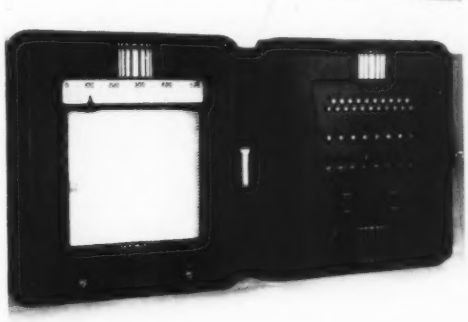
California Precision Castings Inc., 1721-23 *Standard Ave., Glendale* 1, *Cal.*

Bolts and nuts for severe service at elevated temperatures in gas turbines and other highly stressed applications are made of alloy steel, X-40, originally developed by The National Development and Research Committee during the war. This metal is composed of carbon 0.45-0.60 percent, chromium 23-28 percent, nickel 9-12 percent, and tungsten 6-9 percent. At room temperature ultimate tensile strength is 113,000 psi and at 1,500 F strength is 60,000 psi. After aging 50 hr at 1,350 F, metal shows 75,000 psi tensile strength and 4.6 percent elongation. Stress rupture strength is 23,000 psi after 1,000 hr service at 1,500 F. Manufacturer states that fasteners will resist oxidizing and reducing atmospheres up to 2,100 F. These nuts and bolts are manufactured to order.

Temperature Indicator and Recorder

Leeds & Northrup Co., 4934 *Stenton Ave., Philadelphia* 44, *Pa.*

Equipment, consisting of two parts, a recorder and switch assembly, logs up to 160 separate thermocouple temperatures in succession at the rate of 4 sec per point. Because each point is checked with such frequence, any high or low temperatures that may develop can be spotted before serious trouble results. Also, in case of emergency, the operator can cut thermocouples out of the measuring sequence in banks of 20 until the instrument is concentrated on a particular group of temperatures. In ordinary operation instrument simply indicates while num-

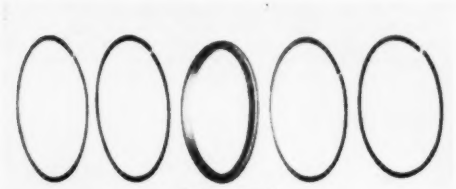


bered lights identify each couple; but when any temperature reaches a preset limit, recording chart drive starts to record all points as a series of numbered dots, and operates an alarm.

Ring Packing

Greene, Tweed & Co., North Wales, Pa.

Tested at pressures up to 10,000 psi, packing is applicable for such industrial uses as seals in cylinders, swivel joints, struts and other applications with either impulsed or constant pressures. Known as the Palmette G-T Ring Packing, part consists of a T section sealing ring of synthetic rubber backed up on both sides by two ring retainers. These retainers are split, and are made of laminated



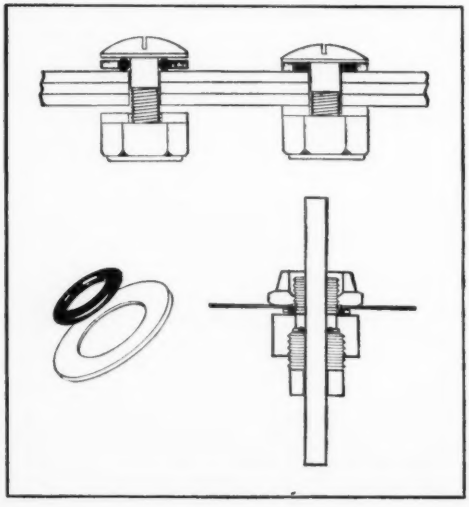
Piston assembly

phenolic. As operating pressure increases, ring flange expands radially against retainers. Packings will operate at temperatures from —70 to +250 F and at pressures up to 3,000 psi. Made in two styles for piston and rod assemblies, packing was originally designed for aircraft hydraulic systems.

Sealing-Action Washers

The Franklin C. Wolfe Co., 407 Commercial Center St., Beverly Hills, Cal.

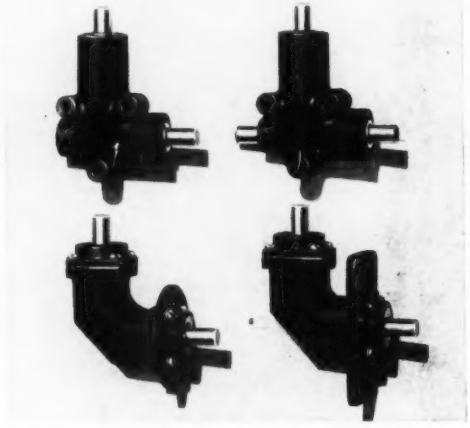
Washers, known as Lock-O-Seal, give positive seal around screws, bolts, rivets, tubing and electrical wiring. The 4130 steel retainers prevent the rubber ring from being compressed beyond its elastic limit. The O-ring, molded of Thiokol SA-710, is inert to atmospheric elements, salt water, oil, gasoline and most organic solvents. Washers are available in two series, 200 and 500, and in sizes up to 2 in. ID. The Series 500, for use in sealing applications with temperatures up to 500 F, has rings molded of silicone. Originally developed for aircraft use, washers are recommended by the manufacturer for industrial hydraulic systems, air conditioners, refrigeration equipment and compressors.



Angle Gear Assemblies

Airborne Accessories Corp., 25 Montgomery St., Hillside 5, N. J.

Angle gear assemblies of various design, as shown, have hardened gear teeth, heat-treated shafts with cadmium plated extensions on heavy duty units, and stainless tubular shafts on medium duty assemblies. Heavy duty models R-160 and R-190 are rated at 500 in. lb ultimate static load, and medium duty models R-200 and



R-210 are rated at 250 in. lb. All units have aluminum alloy housings, and all materials, tolerances and lubricating designs are suitable for operation in temperatures from —65 to +160 F. Although originally developed for aircraft applications, these assemblies also have industrial uses.

Time Delay Relays

American Gas Accumulator Co., Agastat Div., 1029 Newark Ave., Elizabeth 3, N. J.

Relays, under trade name, Agastat, are electro-pneumatic time delay switching devices. They consist of a pneumatic timing head, a solenoid assembly and a switch and terminals. A diaphram and cap encase the head, providing a dustproof timing chamber in which the air used for timing is recirculated. A normally closed auxiliary switch affixed to the bottom of the terminal box acts as a hold-in switch. When the instrument is not energized, the contacts of this switch are held open, and when the coil is powered contacts close. Type 1 Agastat starts time delay when the coil is energized, and Type 2 originates the

TYPE "A" ASSEMBLY BIT

COMMON SCREWDRIVER

On Call... ALL STANDARD CLUTCH HEADS

On Short Order... "SPECIALS" TO SUIT

Plant expansion, with greatly increased production facilities, has freed us from the bug-a-boo of the back-log.

More than that, it has resulted in the establishment of "banks" at the factories. Thus CLUTCH HEAD Screws, in virtually all standard sizes and types, may be called for with assurance of fast deliveries.

Likewise, with these extended facilities, you can rely on speedy action going behind your requirements for "Specials" to meet your specifications.

As always, CLUTCH HEAD is truly *"On Call"* for the delivery of safety and savings with features that are unequalled by any other screw on the market today.

Start your investigation of America's Most Modern Screw by sending for assortment of screws, sample Type "A" Bit and illustrated brochure

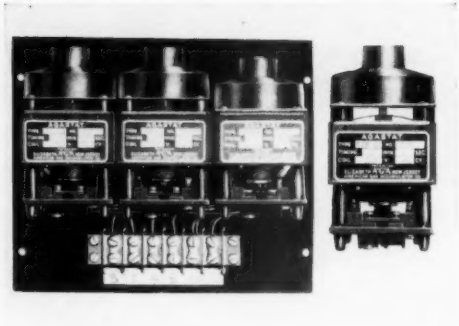
Only in CLUTCH HEAD *do you get the dual safety of automatic dead-center entry and non-tapered driving for zero in skid damage . . . plus easier driving with freedom from fatiguing end pressure to buck "ride-out." Only* CLUTCH HEAD *has the Lock-On to hurdle "fumble spots." Only* CLUTCH HEAD *has a*

CLUTCH HEAD SCREWS

Type "A" Bit rugged enough to drive 214,000 screws non-stop . . . and that can be repeatedly reconditioned on-the-spot in 60 seconds. And CLUTCH HEAD *alone simplifies field service with a recess that is basically designed for operation with a common screwdriver.*

UNITED SCREW AND BOLT CORPORATION

CLEVELAND 2 CHICAGO 8 NEW YORK 7

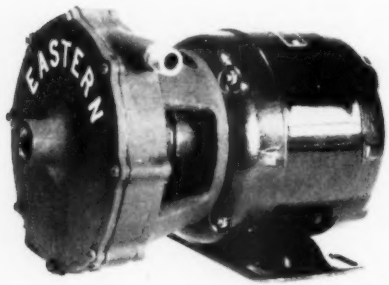


delay when the coil is not energized. Coils for 110 or 220 v, 60 cycle a-c consume about 6 watts. Time delay control varies from 0.1 sec to 5 min or more.

Centrifugal Pump

Eastern Industries Inc., 296 Elm St., New Haven 6, Conn.

Model H centrifigal pump is designed for applications where moderate pressures and volumes are required from a pump running at 1,725 rpm. The performance curve



shows a shut-off pressure of 19 psi. Pump will deliver 10 gpm at 15 psi, 15 gpm at 10 psi, and over 20 gpm at free flow. The pump is constructed of either bronze or aluminum with a mechanical rotary seal. The inlet is $\frac{1}{2}$ in. NPT female and outlet is $\frac{3}{8}$ in. NPT male. Units are available with motors ranging from $\frac{1}{6}$ to $\frac{1}{3}$ hp, depending on operating range desired. With $\frac{1}{6}$ hp motor, the overall pump size is about 12 x $7\frac{1}{2}$ x $8\frac{1}{4}$ inches.

Vibration Meter

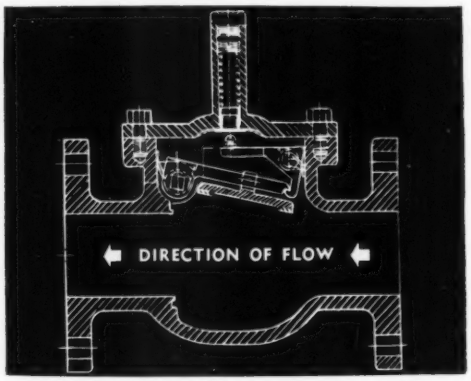
General Electric Co., Apparatus Dept., Schenectady 5, N. Y.

Gas turbine meter, which measures vibration displacement, velocity and acceleration, consists of a vibration detector, an amplifyer with indicating instrument and, when desired, a remote indicating instrument for panel mounting. The meter has a vibration frequency range, without filters, of 30 to 300 cps. External filter also permit measurements in the range of 14 to 20 cps. A selector switch provides a choice of full scale readings of 0.1-300 in. per sec average vibration velocity, and 1-3,000 mils peak-to-peak vibration displacement. Accuracy is within ± 5 percent of full scale reading and meter operates on a 33 w, 110-125 v, 60 cycles.

Gate Valve

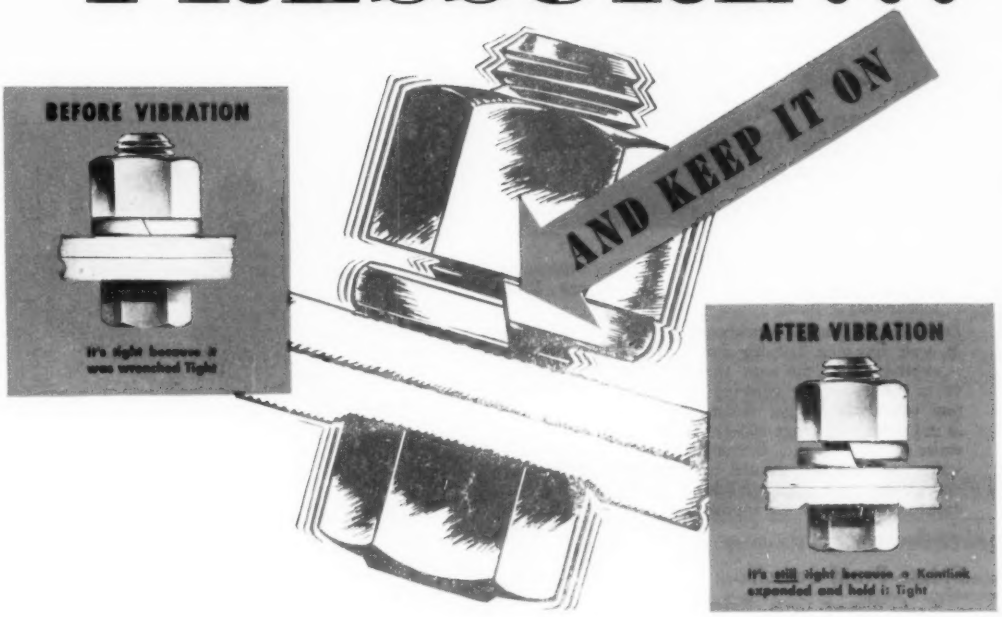
Security Valve Co., 410 San Fernando Rd., Los Angeles 31, Cal.

Model S valves are designed for compressed air, gas, oil and hydraulic lines. The spring-actuated gate is set to close at a pressure specified by the application. The



diaphram is made of Nylon fabric, impregnated with synthetic rubber. Overhead positioning of this diaphram lessens the possibility of line condensate affecting the valve operation. The valve disk has a molded, synthetic rubber face, and the orifice area is equal to that of the pipeline. When the nut at the assembly top is removed, the internal set screw can be tightened to compress the spring which depresses the latch to release the gate and close the valve. Available sizes vary from $\frac{3}{4}$ to 8 inches.

Put on the
PRESSURE...


BEFORE VIBRATION
It's right because it was wrenched Tight
AND KEEP IT ON
AFTER VIBRATION
It's still right because a Kantlink expanded and held it Tight

No nut can turn loose on its bolt so long as there is pressure on its threads.

Kantlink spring washers keep that pressure on. There is no substitute.

The first loosening or wear of bolted assemblies comes in the other parts, not from the nut turning on the bolt. Ductility may permit slight bolt stretch, or the gradual friction of metal on metal, or the grinding down of burrs, flares, or the pulverizing of scale, rust or paint—these things cause inevitable loosening unless a strong expanding spring washer keeps the pressure on.

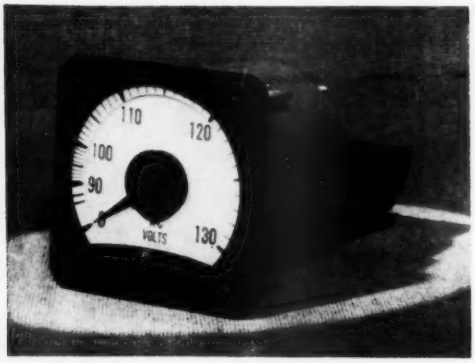
The powerful expansion of Kantlink, as this inevitable wear occurs, gives you ample time to retighten before trouble starts.

For continuous pressure on all your bolted assemblies specify Kantlinks—the wide range helical spring washers that are stronger, and hold all parts tight longer.

Write today for descriptive folder.

Originators of KANTLINK the long-range spring washer

THE NATIONAL LOCK WASHER COMPANY
Newark 5, New Jersey **Milwaukee 2, Wisconsin**



Expanded Scale Voltmeter

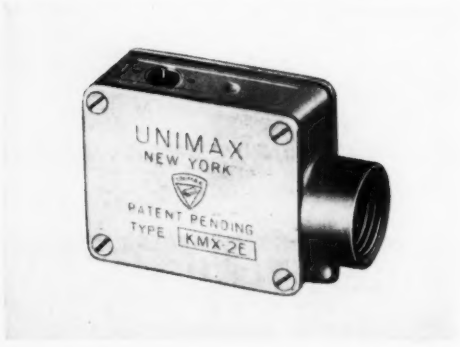
General Electric Co., Meter and Instrument Div., Schenectady 5, N. Y.

Designed for general switchboard use, voltmeter has 7.1 in. scale spanning 250 deg about the center. This scale is expanded over the most frequently used range from 90 to 130 v, thereby allowing readings of 0.5 v variation within that range. Accuracy has been determined to $\pm\frac{1}{2}$ percent in range 105-125 v, and ± 1 percent over entire expanded range. Instrument can be supplied with scales applicable to potential transformers with voltages higher than 130 v. Meter is housed in dustproof case the dimensions of which are approximately 4 x 4 x 6 inches.

Splash-Proof Switch

W. L. Maxson Corp., Unimax Switch Div., 460 W. 34th St., New York 1, N. Y.

Model KMX switch has die cast aluminum housing which affords protection against splashing oil, moisture and abrasives. The metal housing can be installed separate from the switch; and is applicable for side mounting with threaded studs which project from the side plate, or for base mounting with tapped base holes or adapter flange. Independent mounting of switch and housing permits connection to terminals before switch is set in housing, thus facilitating installation and switch circuit changing. Neoprene gaskets fit the side plates, and a neoprene diaphragm on the top of housing seals the junction where stainless steel pin transmits operating force to switch element. Conduit hub connection has $\frac{1}{2}$ in. internal pipe thread diameter. Dimensions are 2 x $1\frac{1}{4}$ x $\frac{7}{8}$ inches.



Thickness Microscope

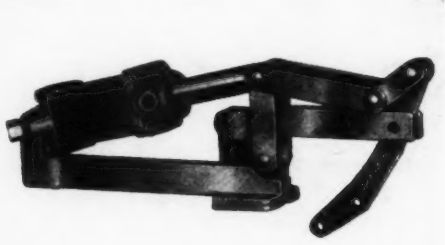
Instrument Development Laboratories Inc., Williston Park, Long Island, N. Y.

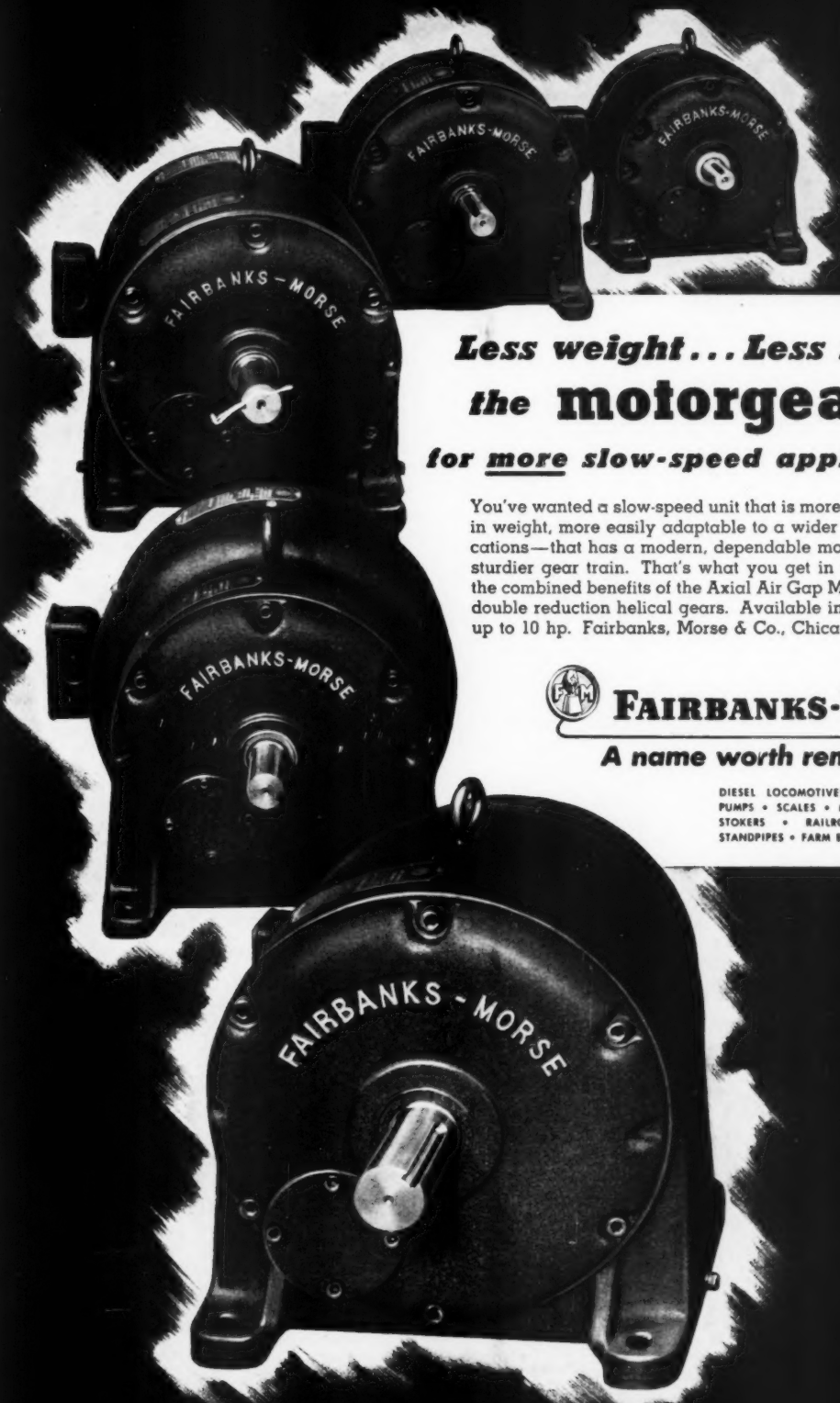
Instrument measures the thickness of glass, plastics, quartz or any other transparent material under conditions where physical access to only one side is possible. The instrument will measure wall thickness to an accuracy of 0.001 in. The production model will measure thickness up to 0.4 in., and can be adapted to increased thickness measurements on special order. It has equal facility in measuring flat, concave or convex curved materials having smooth ground or patterned surfaces. Operating on the depth-of-focus principle, the accessible surface is in contact with the measuring head and the inaccessible surface is located by adjustment of the graduated dial until a lamp image is brought to sharp focus.

Toggle Clamp

Lapeer Mfg. Co., Lapeer, Mich.

Model DTAO-400 clamp has a plier-like grip which is produced by the toggle bar and jaw. In operation, both the bar and jaw swing clear to allow free removal of work. The supporting pressure of the toggle bar is 400 lb at the outer rivet and 300 lb at the inner hole. Clamp will maintain its grip on work although there is an accidental failure in the air pressure line, and will not release work until air pressure is again supplied. Operating air pressure is 85 lb, and overall dimensions of open clamp are about 8 x $2\frac{1}{8}$ inches.





Less weight . . . Less space

the motorgear

for more slow-speed applications

You've wanted a slow-speed unit that is more compact, lighter in weight, more easily adaptable to a wider variety of applications—that has a modern, dependable motor with simpler, sturdier gear train. That's what you get in the Motorgear—the combined benefits of the Axial Air Gap Motor and modern double reduction helical gears. Available in standard ratios, up to 10 hp. Fairbanks, Morse & Co., Chicago 5, Ill.

FAIRBANKS-MORSE

A name worth remembering

DIESEL LOCOMOTIVES • DIESEL ENGINES
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STOKERS • RAILROAD MOTOR CARS and
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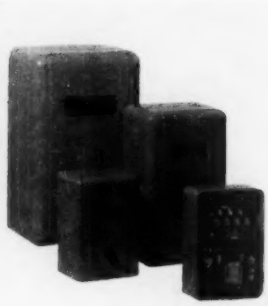


Magnetic Starters

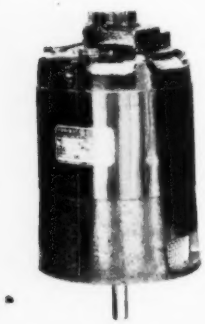
General Electric Co., Schenectady 5, N. Y.

Designed for starting motors up to 50 hp, full voltage starters are furnished in all NEMA sizes from 0 to 3. The contacts are available in sizes from 00 to 3. Plastic coil enclosures protect the windings against dirt and moisture, and self lubricated slots in the side of this enclosure allow movement of the magnet armature guides. Asbestos arc shield prevents arcing over between contacts. Magnet is made of silicon steel and has a permanent air gap to insure quick dropout.

Jet Pump Motors

General Electric Co., Schenectady 5, N. Y.

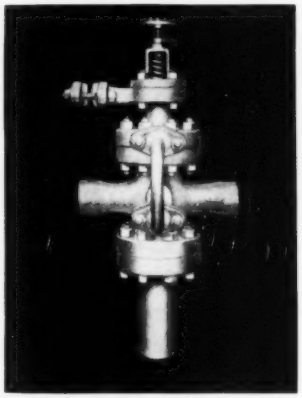
Fractional hp motors for jet pumps in ratings of $\frac{1}{4}$, $\frac{1}{3}$, $\frac{1}{2}$, $\frac{3}{4}$ and 1 hp are available with standard shaft and keyway or with stainless-steel, threaded shaft for direct mounting of the impeller. Of the four models the KC type is capacitor-start, single phase; the KH is split-phase, single phase; the K is induction, 3 phase; and the BC model is a compound wound, d-c motor. Clockwise rotation is used in all four types, and the single phase models have a built-in automatic reset Thermo-Tector for overload protection. The voltages and frequencies used with these models vary from 115 to 440 v and 50 to 60 cycles.



Pressure Reducing Valve

Leslie Co., 233 Delafield Ave., Lyndhurst, N. J.

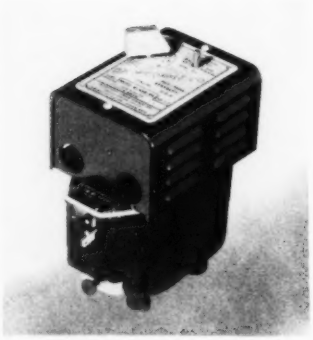
High pressure reducing valve, known as Class HS, is designed for steam, air or gas service. Equipment handles inlet steam pressures from 300 to 1,500 psi, and air or gas inlet pressures from 300 to 3,000 psi. Reduced pressure range is from 100 to 600 psi, and maximum inlet temperature is 1,000 F. Body is cast chrome molybdenum steel with integral stellite seating surface. Valve is single seated, closing with the inlet pressure for positive deadend shut off, and is available in 1, $1\frac{1}{4}$ $1\frac{1}{2}$ and 2 in. sizes with welding ends or Series 90 or 150 flanges.



Furnace Air Controller

D. H. McCorkle Co., Box E, Station A, Berkeley, Cal.

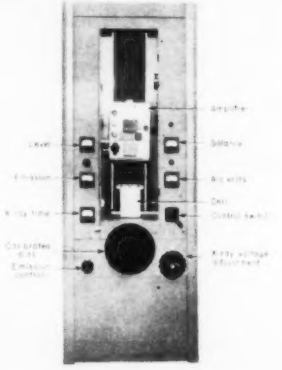
For industrial oil furnaces, this control allows the selection of motor speeds that will give the proper air for complete combustion at low, medium and high fire. Designed to be mounted on standard level valves and to be operated by an extension rod, the control measures about 4 x 5 x $2\frac{3}{4}$ in., and operates on 110-115 v circuit. An overrun switch is included to allow the blower to run at full speed, regardless of the setting of the metering valve. This permits the clearing of oil from furnace after the firing period.

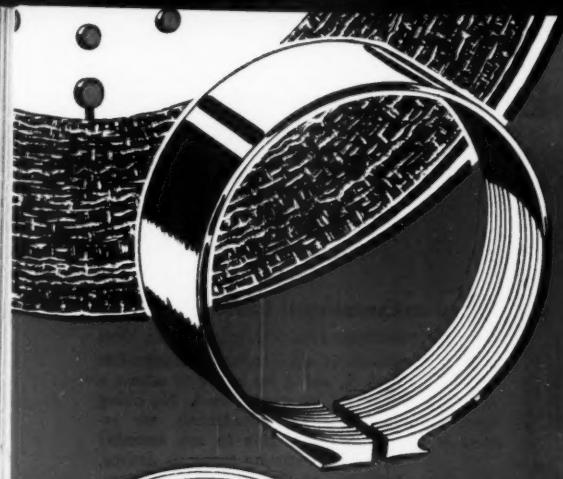


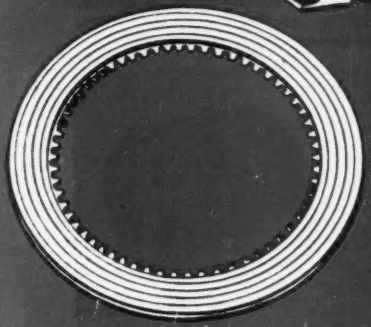
X-Ray Photometer

General Electric Co., Special Products Div., Schenectady 5, N. Y.

Photometer is used for rapid determination of concentration of one element or compound in the presence of others. Difference in X-ray absorption is measured between a sample and a reference standard. In this null-balance instrument the X-ray source and receiver serve commonly for two beams—one beam passes through the reference and the other through the sample. To make an analysis, absorption of X-ray beams is brought to balance by introducing a sufficient thickness of aluminum into one beam to equalize both beam attenuations. The amount of change of thickness of this aluminum between any two samples is a function of the difference in chemical composition. Specimens







HOW TO SAVE A BIG STEP ON SUB-ASSEMBLY LINES

Whatever your problems in brake or clutch assembly, you'll find the R/M representative a good man to consult. In many cases, he is able to make suggestions that save steps and save time in assembly operations.

Here's an interesting example. Where specifications call for a friction material bonded to a metal backing . . . a development with which you may not yet be familiar . . . R/M can supply the *complete* sub-assembly, finished to your special needs. You thus eliminate a purchasing operation, as well as several steps in fabrication and assembly!

If it is more practical for you to provide your own backing plate for bonding to the friction component, R/M will, without cost, provide manpower for instruction in the bonding process. The "know-how" is yours for the asking!

For further information, check with your R/M representative. At his call, ready to serve you, are four plants, four research staffs, and four complete testing laboratories . . . with a half-century's experience in brake and clutch applications.

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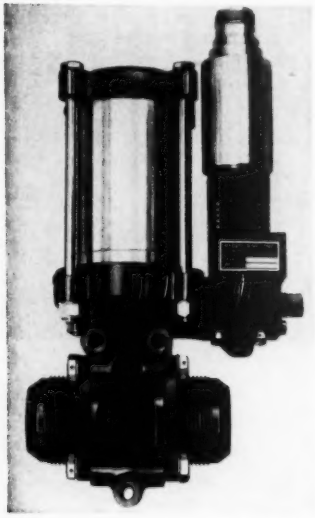
FIRST IN FRICTION

can be in solid, liquid or gaseous state, and equipment requires 115 v, 60 cycle supply along with a cold water source to cool X-ray tube.

Solenoid Gate Valve

Hydro-Aire Inc., 3000 Winona Ave., Burbank, Cal.

Solenoid-controlled gate valve, designed as a shut-off valve for water injection pumps, can be used as a shut-off valve for large fuel pumps or as a control valve to regulate the flow of oxygen, air, alcohol, oil and water. In cases of electrical failure, the valve

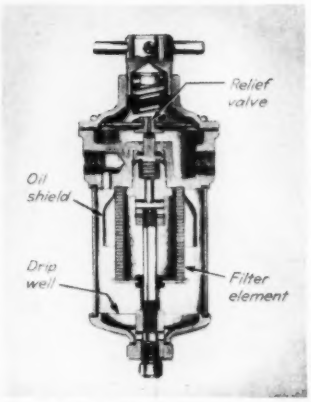


remains in the last energized position. Opening time is adjustable from $\frac{1}{4}$ to 5 sec; closing time is less than 1/10 sec. Valve will operate at ambient temperatures from —65 to +250 F, and can handle air or liquid temperatures up to 550 F. At 250 F the valve consumes 5.5 amp at 17 volts.

Combination Regulator Filter

Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa.

Model FH-15 combines the functions of a reducing-relief valve and an air filter. All parts of the unit are of either forged brass or stainless steel. Filter medium is a phenolic-resin impregnated cellulose cylinder capable of removing particles as small as 40 microns. Single through-bolt construction permits removal of the filter element by loosening and removing only



one nut. This element can be cleaned by dipping in a solvent, such as gasoline. A space is provided below the filter element which acts as a dripwell for oil and water. Pressure ranges are 0-30 psi and 0-60 psi with $\frac{1}{4}$ in. NPT connections for inlet pressures up to 150 pounds per square inch.

Level-Control Valves

The Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio.

Flow-actuated level-control valves are designed for controlling the flow of fuel in jet or reciprocating aircraft fuel transfer and single point fueling systems. The valves operate in a 1-50 psi pressure range. In operation, they bypass a small amount of line flow to a pressure-balanced pilot valve actuated by the small float. When the float closes against the frictional resistance of the lapped pilot piston, pressure builds up in the pilot line to close the

main valve. The balanced pilot valve thus operates independently of pressure and flow rates, and so maintains uniform levels in any liquid tank. Valves will operate in temperature as low as —65 Fahrenheit.

Centrifugal Clutches

Yoder Clutch Corp., Orrville, Ohio

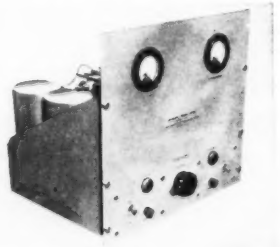
Clutch is designed to accommodate $\frac{1}{6}$, $\frac{1}{4}$, $\frac{1}{3}$, and $\frac{1}{2}$ hp rating to relieve a motor of its starting load. No oiling or mechanical adjustments are required. Applicabie to any assembly where high starting torque is desired, such as air compressors or pumps, mechanism is available in $\frac{1}{2}$ and $\frac{5}{8}$ in.

bores with $2\frac{1}{4}$ in. OD and a standard 2 in. V belt sheave. Type of engagement is regulated by the nature of application.

Power Supply Regulator

Chatham Electronics, 475 Washington St., Newark, N. J.

This laboratory instrument, known as Model E-48, has been designed to give a closely regulated source of ripple-free d-c voltage. This equipment will give less than 0.05 v peak to peak ripple and less than 0.15 percent variation in output from noload to full load. Input power is 105-125 v, 60 cycles a-c and output can vary from 160 to 1,500 v, 125 ma, d-c. The instrument can be either relay rack mounted or housed in a cabinet for bench use.



Time-saver for machine designers
. . . the complete CRANE line

ONE SOURCE OF SUPPLY
RESPONSIBILITY
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Why spend valuable hours looking for piping equipment when one catalog contains everything you need? It's the Crane Line that gives you the world's most complete selection of valves, fittings, pipe and accessories—the finest quality—in brass, iron, steel and alloy materials.

For This Pneumatic Stuffer with a minimum of piping—as for an intricate bottle washer—the Crane Line can be a real time and work saver. Regardless of the design on your boards, Crane is the **One Source of Supply** complete enough to speed and simplify all piping procedures, from specifications to finished product.

One Responsibility for piping equipment facilitates buying and storekeeping; helps to assure better control of product assembly operations in the factory. Moreover, your product gains added value when it's Crane equipped. For wherever fluids are handled, Crane stands for **High Quality** in piping materials.

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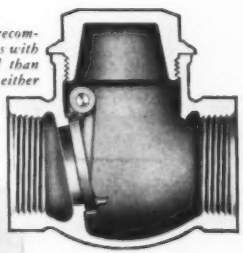
Pneumatic Stuffer for meat products by the Globe Company, Chicago

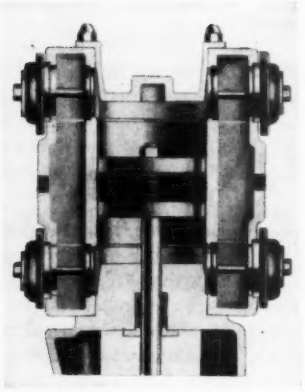
FOR STEAM AND WATER LINES, *Crane recommends No. 34 Brass Swing Check Valves with brass disc. Heavier and more rugged than usual "standard" valves; may be used either in horizontal position, or in vertical position for upward flow. Working pressures: 125 pounds steam, 200 pounds cold water, non-shock. Sizes: ⅜ to 3 in. See your Crane Catalog, p. 55.*



EVERYTHING FROM . . .
VALVES • FITTINGS
PIPE • PLUMBING
AND HEATING

CRANE

FOR EVERY PIPING SYSTEM



Carbon Graphite Piston Rings

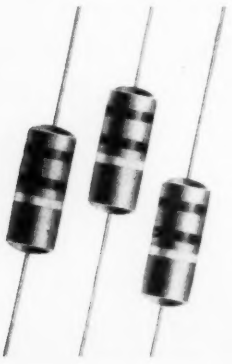
Morganite Inc., Long Island City 1, N.Y.

Piston rings for air, steam, or gas compressors are made to order in any size required. Constructed of carbon graphite, these parts are self-lubricating so that there is no need for liquid lubricants which in some applications would contaminate gases being compressed. Rings are chemically inert and impart no taste, color or odor. Strength is compatible with most operating requirements, and rings can be repositioned to compensate for wear before replacement is necessary.

High Voltage Resistors

International Resistance Co., 1100 Terminal Commerce Bldg., Philadelphia 8, Pa.

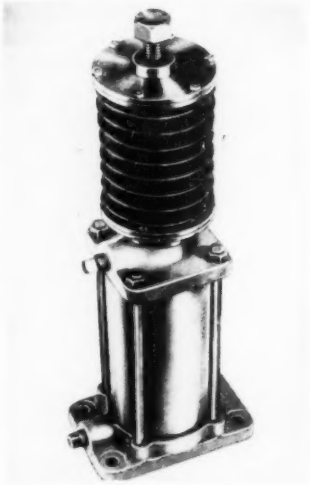
Designated as type BTVA, these resistors are a variation of the Advanced BT model. In construction BTVA is much the same as model BT, but internal part of lead wires is shorter. This leaves a wide air gap between lead ends, and permits resistor to operate continuously at potentials up to 2,000 v and to withstand surges up to 6,000 v. This product can be used for such applications as a discharge resistor across a capacitor in fluorescent ballasts, in television bleeder circuits or as a meter multiplier.



Shaft Seals

The Garden Mfg. Co., New Castle, Pa.

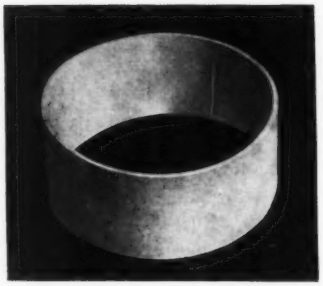
Bellows-type seals are for use around any reciprocating or sliding shaft. As shown, these bellows have been used to protect hydraulic cylinders and also can be adapted for such applications as flexible duct connections, expansion seals and sliding bearings. The seal, which can be made either of canvas or rubberized fabric, acts as an accordion to follow the shaft movement. The standard available range of sizes fit 1 to 6 in. shaft diameters.



Silicone Flexible Duct

The Connecticut Hard Rubber Co., 407 East St., New Haven 9, Conn.

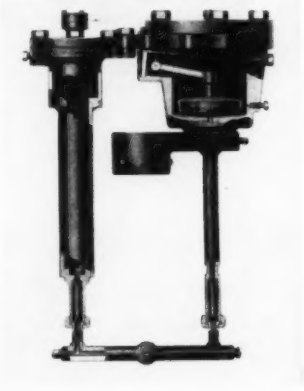
This product is fiberglas reinforced silicone rubber designed expressly for use in aircraft. It is available in cylindrical sections as shown and is used as flexible connection ducting. The sleeve will permit the passage of air at temperatures up to 550 F, will withstand internal pressures of 5-10 lb without leakage and will remain flexible at temperatures as low as —75 F. This material is mandrel wrapped, and is not manufactured with regular coating equipment. According to the manufacturer, this method of processing gives a greater selection of ply thickness and reinforcement which is varied according to specific requirements.



Mercury Manometer

Taylor Instrument Co., P. O. Box 110, Rochester 1, N.Y.

Model 1500, mercury manometer has a working pressure of 1,500 psi and will operate in ranges from 10 to 400 in. of water. Built for use on indicating, recording and controlling instruments, two such manometers can be mounted on a single case for recording two flows or for ratio flow control. Over-range protection is provided by the positive acting check valves as shown submerged in the mercury. Interchangeable range chambers make the manometer so adaptable that no pipe changes are required when changing from one range to another.



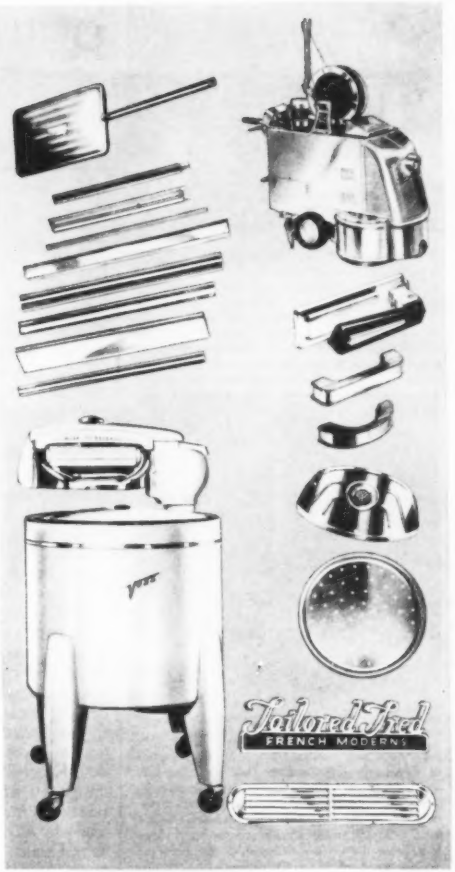
NICKELOID ZINC BASE METALS BEING UTILIZED TO REAL ADVANTAGE

In the choice of base metal for pre-plated parts on consumer products, the manufacturer many times has a tendency to overlook the many advantages of zinc. In purchasing his plated sheets or coils he may first think of steel or aluminum base — or brass and copper.

In cost, zinc base plated sheets or coils occupy a position rather midway between plated steel and, for example, plated copper. Plated zinc is easily worked and thus is adaptable to blanking, forming, stamping and other fabrication methods.

Durability of pre-plated zinc is high. As a base metal it is rust-proof and highly corrosion resistant. With zinc as a base metal for platings, the raw edges or unplated metal back is no objection. The finish is beautiful, mirrorlike, and plated zinc is available in a range of gauges and tempers.

Zinc as a base metal may be procured with finishes of either nickel, chromium, copper or brass. It is available in sheets or long continuous coils, plated one or two sides, bright or satin finish. It is also available in crimps and patterns for unusual effects.



Just a few of the hundreds of items manufactured in quantities which employ pre-plated zinc base Nickeloid Metals.

While many metals are short in supply or delivered on an allocation basis thus necessitating anticipation of requirements, sheet or coil zinc is a little easier in supply. Our Peru, Illinois, plant, in addition, is located in the heart of the zinc rolling area where time is saved in delivery. In view of the workability and durable qualties of zinc base metal — it is one of the pre-finished Nickeloid Metals now receiving more than ordinary consideration on the part of manufacturers.

We have just completed a new folder on our pre-plated zinc base metals with finishes of nickel, chromium, copper or brass. Write for it on your company stationery.

AMERICAN NICKELOID CO.

Peru 4, Illinois

Silicone News

DC SILICONES

DC Silicone Fluid Stabilizes Versatile Force Measuring Device

Thrust, torque and other kinds of force are measured by air in a device so sensitive and versatile that the same unit can measure the thrust of a 2000 h.p. engine while responding to the weight of a coin. It is used in the cradle dynamometer measurement of aircraft and automobile engines, the testing of piston rings and axles and automatic batch weighing. And it operates without any movement of the measured system.

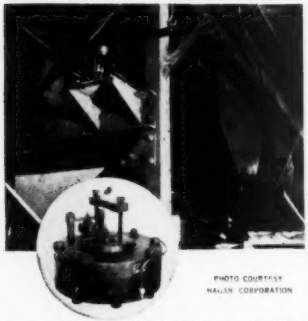


PHOTO COURTESY HAGAN CORPORATION

Accuracy of air operated, null displacement "ThrusTorq" is stabilized by DC 200 Fluid in viscous damper

The "ThrusTorq" made by Hagan Corporation of Pittsburgh is essentially an air chamber, one side of which is a flexible diaphragm. A poppet valve admits compressed air until pressure in the air chamber exactly balances the force exerted on the diaphragm by the torque arm. When the force is reduced, air is exhausted to maintain equilibrium. Air pressure required to balance the force is registered by a manometer, or gauge calibrated in foot-pounds.

But the stability of a system for balancing inertial forces depends upon adequate damping. That is done most effectively by DC 200 Silicone Fluids in a viscous damper consisting of two diaphragm chambers connected by a small orifice in the partition plate.

Critical damping and more compact hydraulic systems both depend upon the remarkably low rate of viscosity change in DC 200 Fluids over a wide temperature range. For more information about these silicone fluids including data on resistance to oxidation and to mechanical shearing, lubricity, water repellency and dielectric properties, phone our nearest branch office or write for booklet C13 H2.

DOW CORNING CORPORATION
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In England: Albright and Wilson, Ltd., London

Dow Corning
FIRST IN SILICONES

OUR READERS SAY

Bearing Problem

To the Editor:

I read the article "Plain Sleeve Bearings" in the October issue of PRODUCT ENGINEERING; and, being unable to find the answer to a bearing problem I have, I wondered if any of your readers had successfully solved a similar one. This is the case with which I am confronted.

I have two bearings, 11 in. between centers, with a $1\frac{3}{8}$ in. dia. connecting shaft. The load at the shaft center is 5,000 lb max, but the assembly will operate at less than 3,000 lb center load. There is also an overhang load on one bearing of 1,500 lb at $3\frac{1}{4}$ in. from the bearing center. The $1\frac{3}{8}$ in. shaft has a close-fitting sleeve 2 in. OD overall, between the bearings. The shaft has an oscillating motion through a 90 deg max angle, but it will operate at times at a much smaller angle. The shaft oscillates at $1\frac{1}{2}$ rpm, and the bearing area is $2\frac{3}{4}$ sq in. per bearing.

Your article mentions shaft deflection as a point to consider in bearing design, but I fail to find any suggested design by which to lessen the deflection. In my problem the deflection tends to align the bearing to the deflected shaft.

This oscillation of the shaft might tend to squeeze out the lubricant. I wondered if a wick feed oiler might allow oil to go to the point of load better than ordinary grease lubrication.

At the moment, I am considering the use of plain bronze bearings with porous bronze or needle bearings as possible alternates. I wonder if anyone can give me some helpful suggestions? —T. A. G.

Ed.—Interested readers should reply to PRODUCT ENGINEERING.

Provocative Abstraction

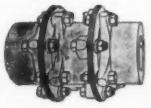
To the Editor:

I am glad to see that PRODUCT ENGINEERING is abstracting worthwhile articles. I was particularly interested in the one in the October issue entitled "Modern Dimensioning Practice". I have used with great success a combination of the main features of SAE and U. S. Army Ordnance dimensioning practice during the past

THOMAS Flexible ALL METAL COUPLINGS

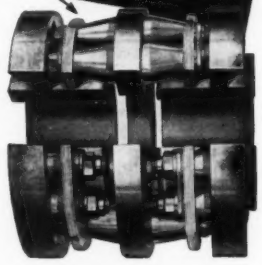
Engineered to stand up on the toughest jobs, Thomas Flexible Couplings do not depend on springs, gears, rubber or grids to drive. All power is transmitted by direct pull.

The standard line of Thomas Couplings meets practically all requirements. But if unusual conditions exist we are equipped to engineer and build special couplings.



BACKLASH FRICTION WEAR and CROSS-PULL are eliminated NO LUBRICATION REQUIRED!

PATENTED FLEXIBLE DISCS



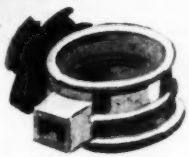
THE THOMAS PRINCIPLE GUARANTEES PERFECT BALANCE UNDER ALL CONDITIONS OF MISALIGNMENT

Write for New Engineering Catalog

THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA

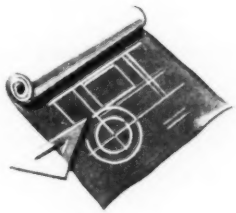
"THE BOARD CHAIRMAN ISN'T BORED ANY MORE!"

The story of a die casting design that solved an engineer's housing problem



"We'd gone along for years stamping this housing. Nobody worried about the high rejects. And the cost was taken for granted.

"I guess we were simply making the most of the facilities we owned and letting it go at that . . . until the day that one of our designers asked himself if it really *had* to be done that way! Anyway, he ended up in a huddle with a Gerity-Michigan man.



"They came up with a housing design for zinc die casting which made us *all* unsatisfied with the old way. Not only did it promise us fewer rejects and simpler finishing, but also more uniform wall thickness and easier machining."

DON'T OVERLOOK ANY PART OF YOUR PRODUCT!

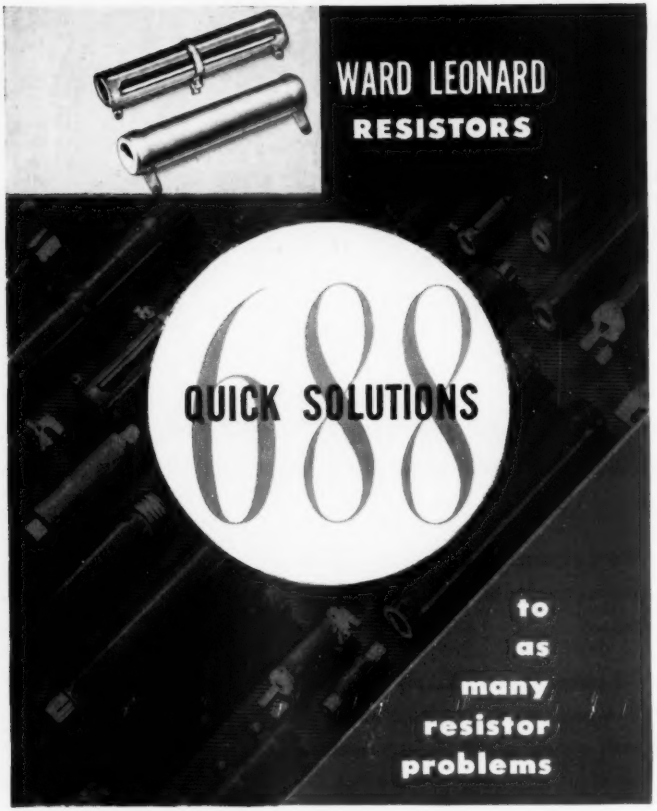
We place at your disposal our many years of experience in meeting the highest specifications of the automotive, aviation and other industries. Gerity-Michigan service begins at the *plan stage*.

We'll gladly consult with you on how to get the most out of zinc die castings. We can also machine the castings for you and finish them in *America's finest plate*—chrome, nickel or silver. Write or phone today. Gerity-Michigan Corporation, Adrian, Michigan.

GOING PLACES IN PRODUCT DEVELOPMENT!

Gerity-Michigan corporation

Adrian, Mich.



because Ward Leonard has that many types of resistors in stock

You can get immediate delivery on Ward Leonard Vitrohm wire-wound resistors—both adjustable and fixed—in watt ratings from 5 to 200 and resistance values from 1 to 150,000 ohms.

Resistive element embedded in Ward Leonard's exclusive crazeless vitreous enamel, gives these resistors consistent accuracy and stability even under the most prolonged adverse operating conditions.

Write for Resistor Catalog D130. Ward Leonard Electric Co., 63 South Street, Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

WARD LEONARD ELECTRIC COMPANY
Result-Engineered Controls
RESISTORS • RHEOSTATS • RELAYS • CONTROL DEVICES

nine years in U. S. A., England and Europe. This was with regard to the design of machine guns.

I hope all your subscribers read the abstract pages, because often times, this section of technical magazines contains invaluable information which a number of readers overlook.

—P. D. COMERY
Liaison Officer
A. V. Roe Canada Ltd.

Electrically Conductive Plastic

To the Editor:

Could you tell use where we can get more information on the electrically conductive plastic that appeared in the January "Highlights" section of Product Engineering? —M. FERRE
Schlumberger Well Surveying Corp.

Ed.—We believe that you can get more details from E. R. Hall Co., 7120¾ Laurel Canyon Blvd., N. Hollywood, Cal.

Liquid Masking Tape

To the Editor:

Please tell me the name of the manufacturer of the vinyl resin masking tape which was briefly discussed in the January "Highlights" section.

—R. M. GERMAN
Vice President
Fox Engineering Co.

Ed—The maker of this item is Ramsell Products Inc., 712 S. Fifth Ave., Maywood, Ill.

More Strength for Fewer Dollars
SEE THE JUNE ISSUE

Heaven Might Help

To the Editor:

It is only recently that I have become fully cognizant of the frailties of human knowledge and endeavor, and it is with a view to altruistic confession that I wish to unburden myself in this letter.

Ever since the days of Noah, scientists have been bombarding the populace with laws and formulas that have not only confused the layman, but also misdirected the ways of the engineer. The work of finding practical uses for scientific achievements is certainly the engineer's job, but if the engineer could only compel scientists to think practically also, thousands of hours of useless work could be saved every year.

Practicality is a very ordinary word. I only wish it was as widely applied as it is spoken. Recently, it was announced that scientists were now able

to create a new satellite for the earth. This is all very well, but who, except poets and song writers, will be able to profit by such an expenditure of mental energy as this project must have consumed? Certainly the Atomic Age has arrived, but it would appear, if the world is to continue as a populized sphere, that a great deal of exertion must be concentrated along constructive, rather than destructive lines.

One does not love a place the less for having suffered in it, unless it has been all suffering, nothing but suffering. Prior to this century, there has been no weapon which was powerful enough to cause global agony as conveniently as that which we possess today. I have no doubt but that others are harboring the same apprehensions as I, and this letter is only calculated to make these general thoughts audible. This is an appeal for action, individual but concerted along useful lines. Since engineers, as practical scientists, hold the reins to atomic power, they are "the unacknowledged legislators of the world." If together they are unwilling to acknowledge their duties, we are left only with the comfort that Heaven might help.

—F. M.
Edinburgh, Scotland

Gas Plating Process

Telegram to the Editor:

Appreciate full information source availability dry plating process described page seven January issue. Considering application chromium to spring steel subject to severe cyclic stresses where embrittlement due electrochemical plating hazardous.

—STUART H. HAHN
Dalmo Victor Co.

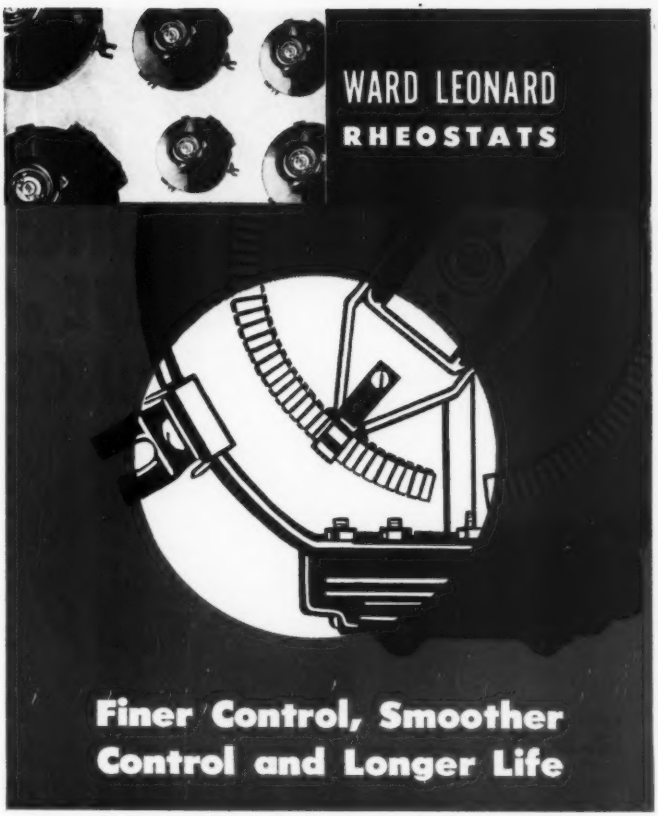
Ed.—Request telegraphed to Commonwealth Engineering Co. of Ohio, developers of new process, whose reply was:

> We know that chromium can be deposited on spring steel by means of the Gas Plating process, but we would like to evaluate your problem thoroughly before advising. . . . . .
>
> —HANS G. BELITZ
> *Sales Engineer*

Torsional Spring Design

To the Editor:

I suppose the principle aim of nomography is to secure time and labor economy in calculations. In accordance with this purpose I studied the nomogram on torsional spring design in the September issue of PRODUCT ENGINEERING. I gathered from the instructions and the numerical example



because of solid rectangular contacts

The greater number of solid rectangular contacts gives Ward Leonard multi-step rheostats finer control with smoother contact arm operation—and with all the advantages of the Vitrohm construction.

The solid metal contacts, connected to the resistance element by a patented Ward Leonard method and embedded in vitreous enamel—assures a mechanically and electrically perfect joint for long and constant service.

Write for Rheostat Catalog. Ward Leonard Electric Co., 63 South Street, Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

WARD LEONARD ELECTRIC COMPANY
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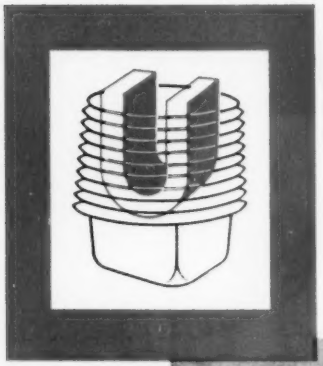
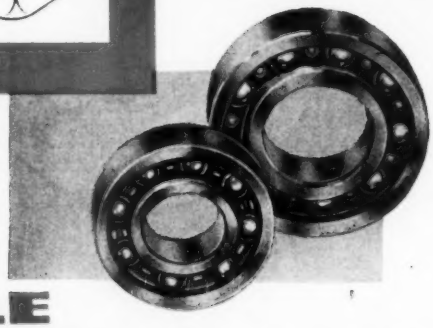
a Magnet



PROLONGS THE LIFE of BEARINGS



LISLE *Magnetic* DRAIN PLUGS

TRAP ABRASIVE "WILD METAL"

The powerful magnet in a Lisle Magnetic Drain Plug attracts and holds abrasive "Wild Metal" that flakes off moving parts and circulates in the lubricant. These minute, razor-sharp particles accumulate under the best conditions, through normal wear. Traveling through the oil system, they cut, grind and gouge in bearings and raceways—break down precision tolerances and prove a major cause of excessive, premature wear.

Specify Lisle Magnetic Plugs in place of ordinary drain or fill plugs to TRAP this "Wild Metal" before it shortens bearing life in the equipment you make.

Sample Magnetic Plugs for testing purposes will be sent without charge. WRITE for free samples and interesting application data.

LISLE *Corporation*

811 EAST MAIN STREET • CLARINDA, IOWA

Makers of Lisle Ridge Reamers and a Full Line of Automatic Tools

given that the author is using the chart for calculating the stress caused by a definite torque applied to a spring made from material of definite size and mechanical properties. But it would be more interesting to know how the chart could be used to design a new spring.

I believe that the author is remiss to the extent that he neglects to take certain important factors into account: namely, inside and outside diameter of the spring and the factor of safety. The latter is dependent upon the tensile strength of the material used.

Since the published nomogram gives no consideration of these factors, the designer can only guess at a mean diameter for the spring. But in order to obtain the diameter of spring wire it is necessary to know the permissible stress, or the ratio of the tensile strength of the spring material to the factor of safety. Tensile strength of a spring wire, however, is not constant but varies with the diameter.

While I was trying to use this nomogram, I noticed a mistake in the fundamental stress formula which renders the chart virtually useless. The fiber stress formula is:

$$S = \frac{10.2TC}{d^3}$$

and not $S = \frac{1.02TC}{d^3}$

Applying the correct formula to the solution of the numerical problem as published, the maximum fiber stress is 290,000 psi and not 29,000 psi as given by the chart which was apparently composed on the basis of a faulty formula.

—VICTOR TATARINOV
Consulting Engineer
Pilsen Czechoslovakia

To the Editor:

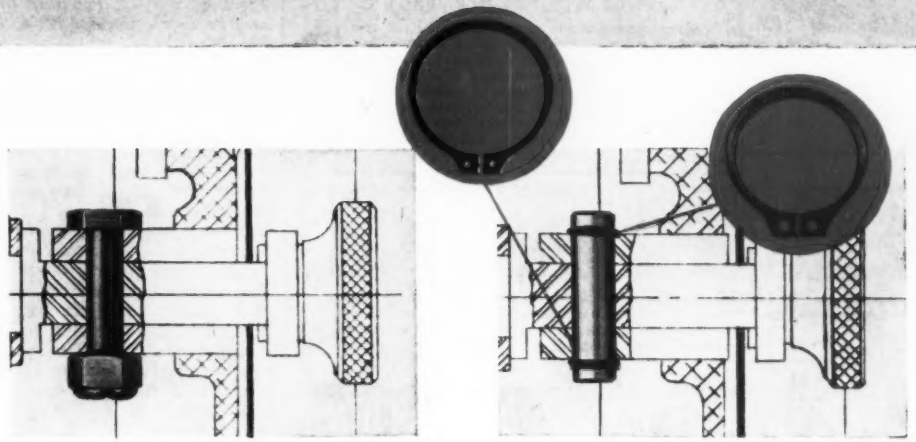
I should like to reply to Mr. Tatarinov's objections to my chart on torsion springs. It is true that tensile strength does increase considerably with finer wires. The author was only concerned with the graphical representation of the formulas. The chart, therefore, does not include a factor of safety. Since designers differ on their choice of other practical variables, these were not incorporated in the chart.

Mr. Tatarinov is right about the arithematical error of ten that I made in the chart as it appeared in the September issue. The graduation on S' should be ten times what they are; and with this the case, these values become too high for practical use. The remedy is to leave them as they are, but drop scale r, vertically 4.83 inches.

I hope that with these explanations the chart is now useable.

—CARL P. NACHOD
Nachod & U. S. Signal Co., Inc.

Truarc saves 5 minutes, 9 cents in materials per unit without re-design of electric sanders



OLD WAY

Special ¼" cap screw and ¼-28 fibre-insert nut holds idler arm and pulley assembly on Model A3 "Take-About" Sander, Porter-Cable Machine Company.

NEW WAY

Simple ¼" C.R. shaft, grooved in automatic screw machine, equipped with Waldes Truarc Retaining Rings. Bowed external ring (#5101-25) at top exerts resilient pressure taken up by Standard external ring (#5100-25) at bottom. Assembly is secure against vibration, can be easily taken apart and re-installed many times with same Truarc rings.

Every sander through the production lines costs 9 cents less for materials, requires 5 minutes less labor —with just the simple change from cap screw and nut to Waldes Truarc rings by Porter-Cable Machine Company, Syracuse, New York. The change to Truarc required no new design, no alterations in castings, but just the reappraisal of old methods.

Truarc can help you cut costs and increase production, too. Wherever you use machined shoulders, nuts, bolts, snap rings, cotter pins—there's a Truarc ring that does a better job of holding parts together. All Waldes Truarc Retaining Rings are precision engineered, remain always circular to give a never-failing grip.

Send us your drawings. Waldes Truarc engineers will be glad to show how Truarc can help you.

WALDES

TRUARC

REG. U. S. PAT. OFF.

RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK

WALDES TRUARC RETAINING RINGS ARE PROTECTED BY U. S. PATS. 2,202,948; 2,029,454; 2,416,852 AND OTHER PATS. PEND.

Waldes Kohinoor, Inc., 47-10 Austel Place PN-4
Long Island City 1, N. Y.

Please send 28-page Data Book on Waldes Truarc Retaining Rings.

Name_____

Title_____

Company_____

Business Address_____

City_____ Zone____ State_____

FLEXIBLE SHAFTS

Wherever power drives or remote control are required, you can depend upon us to produce the Flexible Shafts that will meet the exact specifications. We have years of experience in manufacturing flexible shafting for all types of industry. If we do not have what you require in stock, we can make shafts to your specifications. Our engineers will be glad to work out your problems without obligation.

MACHINERY ELECTRONICS AUTOMOTIVE AIRCRAFT

Many new uses for flexible shafts that carry power around any corner have been developed by our engineers . . . in machine shops, electronic, automotive, aircraft, in all industries where power drives or remote control are required. *Write for Manual P. E.*

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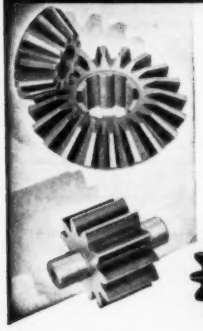
GEARS FOR EVERY INDUSTRY



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NEW BOOKS

The Manufacture of Glass

L. M. ANGUS BUTTERWORTH, *Fellow of the Society of Glass Technology, 274 pages, 6½ x 8½ in. Published by Pitman Publishing Corp., 2 W. 45th St., New York, N. Y. $6.*

A learned study dealing with the history and development of the glass industry from the work of the early Egyptians to present days methods as practiced in countries all over the world. The book is conveniently broken down into sections covering: History, compositions and properties, plants and machinery, manufacturing processes and products and uses.

The reading matter is illustrated by sixty-seven pictures concerned with the art of glass making from the days of Pompeii to the modern spinning of Fiberglas yarn. Notable chapters discuss optical glass, scientific glass, the evolution of sheet glass manufacture and the ways in which architectural glass has been used. An additional section of this book contains a brief study of the geographical distribution of the glass industry. The author has shown a generous amount of esthetic taste in the chapter on stained glass which follows that noble art from its origins to its decline.

Elementary Physical Metallurgy

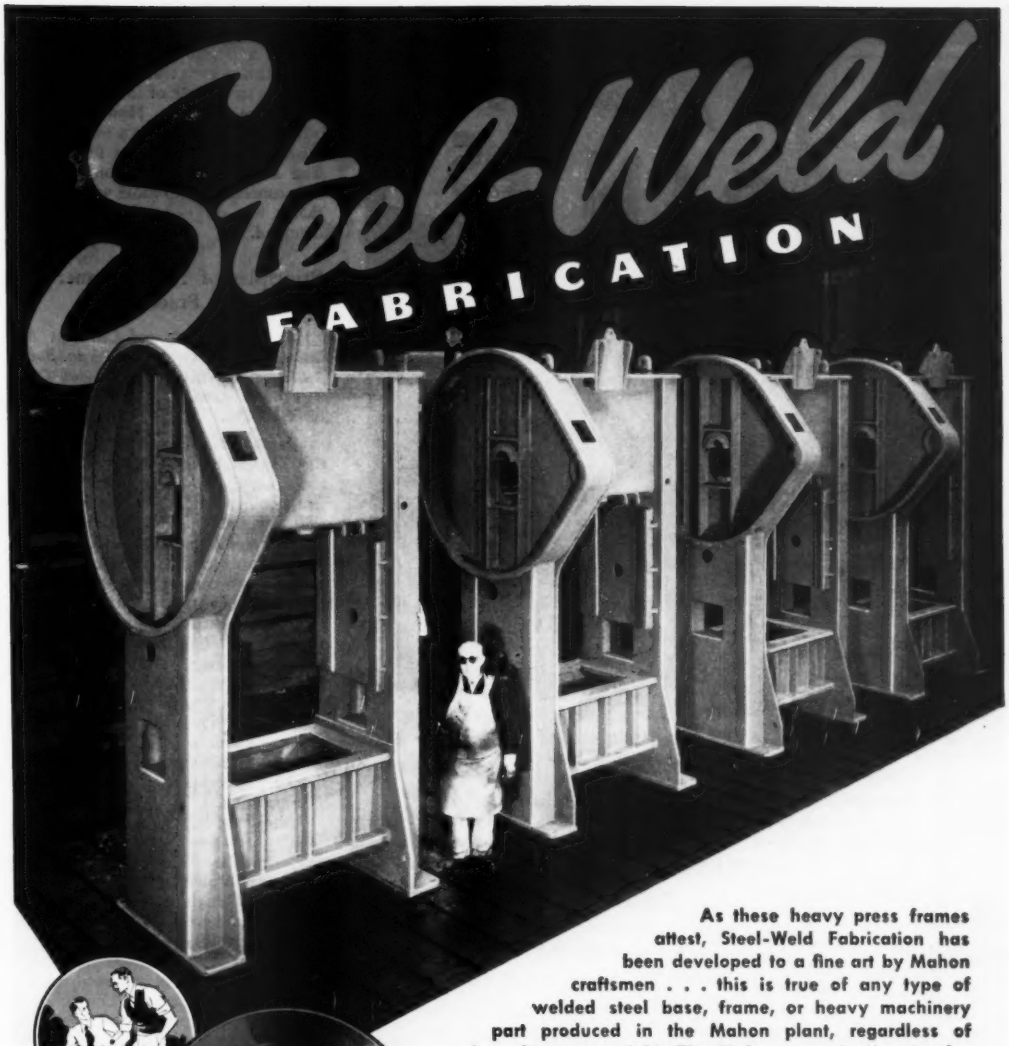
EDWARD G. MAHIN, *Head of the Department of Metallurgy, University of Notre Dame. 276 pages, 5½ x 8½ in. Published by Remsen Press Div., Chemical Publishing Co., Inc., Brooklyn, N.Y. $6.*

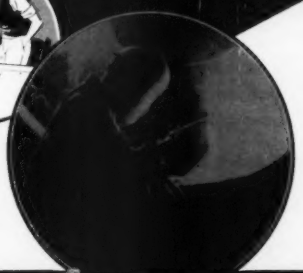
The author has used the well-recognized fact that the principles that are fundamental to the physical metallurgy of the iron-carbon alloys are also fundamental to other metals. For this reason the book has a unity that it would probably lack had the emphasis not been placed on ferrous metallurgy. A little mental interpolation can direct the manifested principles into the realm of other materials.

The first five chapters investigate metallorgraphy, mechanical properties of metals, pyrometry, the iron-carbon system, and crystal space lattices. Concise and fairly detailed accounts of hardness testing and pyrometry augment the more fundamental discussions.

In the last half of the book attention is centered upon mechanical deformation, grain size, thermal threatment, cast irons, surface hardening and

Steel-Weld FABRICATION





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non-metallic inclusions. The author has consistently digested the material so that it is comprehensible to beginners—this is even true of the more exhaustive treatments of thermal analysis and phase diagrams. Nowhere is the writer garrulous, and, as a result, many subjects are covered in a few pages. The slimness of this volume should be a concern only to those who believe that a box car is needed to house a diamond.

Principles of High-Polymer Theory and Practice

ALOIS X. SCHMIDT *and* CHARLES A. MARLIES. *743 pages, 6¼ x 9¼ in. Published by the McGraw-Hill Book Co., 330 West 42nd St., New York* 18, N. Y. $7.50.

The authors, who are connected with the Chemical Engineering Dept. of the College of the City of New York and who have had a good deal of practical experience in this field, present in this book a guide to the underlying principles of plastics materials. This book gives a comprehensive treatment of the fundamental principles, concepts and practice applicable to all materials of high molecular weight, including plastics, rubbers, fibers, surface coatings, adhesives, or wood products. A broad coordinated approach has been maintained throughout, to provide a basic understanding of the formation, properties, manufacture and application of high polymer materials.

After introducing the subject by defining the basic concepts of high polymers, the following topics are discussed: Molecular forces, special behavior of high polymers, polymer formation and modification, structures of high polymers, solubility and molecular weight relations, rheology, molding and manipulation, and mechanical and electrical properties. Throughout the volume, comparison with metals is stressed.

Standard Handbook for Electrical Engineers

ARCHER E. KNOWLTON, *Editor-in-Chief and* R. M. SCHOOP, *Assistant Editor. Eighth Edition, 2,311 pages, 9¼ x 6 in. Published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York* 18, N. Y. $12.

The new edition of this handbook has incorporated all of the wartime developments in the electrical field that are in any way capable of commercial application. The combined work of over 100 electrical engineering authorities, this handbook includes systems and measurements, materials

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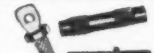

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and methods, authoritative standards, and new developments in equipment from all fields of electrical engineering.

New developments included in this edition are radar and associated microwave techniques; nuclear energy; induction and dielectric heating; new elastomers and plastics and new standardizations. The sections on conductors, generators and transformers, are completely revamped.

The scope of this handbook is indicated by the following representative section headings: Illumination, industrial and commercial power, electric heating and welding, wiring design, commercial and industrial buildings, electronics and electron tubes, codes and standard practices, prime movers, power transmission, power distribution, properties of materials, electrochemistry and electrometallurgy.

Paint and Varnish Technology

Edited by William von Fischer. 509 *pages,* 9¼ x 6¼ *in. Published by Reinhold Publishing Corp.,* 330 *W.* 42*nd St., New York* 18, *N. Y.* $8.

Although this book is written primarily for the manufacturer or formulator of industrial finishes, it is, however, a great interest to the user. It presents a complete survey of the chemistry, formulation, manufacture and applications of paints, varnishes, lacquers and enamels. Originating as a series of lectures at Case Institute, it can be adapted for text book use. Throughout the book the emphasis is on technology aspects, giving information on such subjects as exposure tests, viscosity, film properties, hiding power, special applications and surface preparations.

This book can serve as a single volume survey of the complex field of finishes, since the literature in the organic protective coatings field is limited. Numerous illustrations, charts, tables of data and biographical references are included.

Process Engineering

WILLIAM H. SCHUTT, *President, W. H. Schutt Associates, Industrial Engineers. First Edition.* 304 *pages,* 6 x 9¼ *in. Published by McGraw-Hill Book Co.,* 330 *W.* 42*nd St., New York* 18, *N. Y.* $4.

By process engineering the author means that phase of industrial engineering which interprets the methods and procedures of manufacturing an article economically. It includes: determination of the best sequence of operation, the tools and fixtures to be used and their cost, designation and type of equipment. Furthermore,

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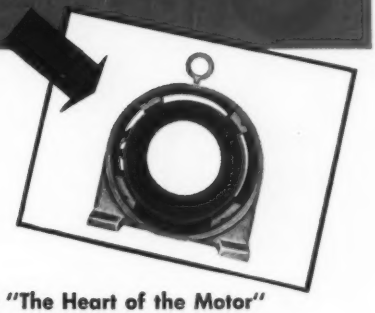

ELECTRO DYNAMIC INDUSTRIAL MOTORS are built in a wide range of types and sizes . . . 1 to 250 H.P. Shown above is an E.D. Drip Proof Industrial Motor. For use under ordinary industrial conditions not requiring protection from splashing liquids or from atmosphere laden with dirt or metal chips.

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Every E.D. industrial motor receives specialized attention at the windings —"the heart of the motor." This extra care and superior insulation materials give Electro Dynamic motors the *plus qualities* of great reliability and long life.

E.D. motors have long been known for staunch dependability in the toughest of all power installations—aboard great ships at sea, under unbelievably severe operating conditions. Now the fine craftsmanship and sturdy construction features of these famous E.D. marine units have been incorporated in a versatile new line of E.D. *industrial* motors, designed to bring to *your* electric power installations the same stamina and trouble-free performance that have characterized E.D. products since 1880.

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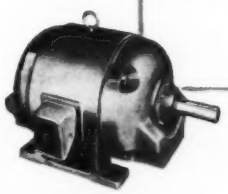
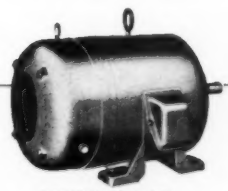


SPLASH PROOF

For installation where the motor is subjected to splashing liquid or hosing down for cleaning.



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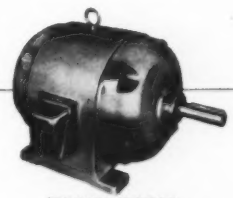
For dirt-laden atmospheres, especially where the installation requires a motor of compact dimensions.



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the process engineer should record certain information that will enable the manufacturer to establish a selling price on the article, as far as the processing cost goes.

In many plants the process engineer's duties are synonymous with those of the estimator. Most estimators, says the author, lack the knowledge and experience for determining the proper tools and fixtures for the operation. The process engineer is one whose knowledge and experience of shop tools, production methods and machinery enables him to establish correctly and scientifically an estimated manufacturing cost of an article. The production engineer is the man in the shop who follows the procedure outlined.

The first seven chapters cover the general subjects with which the process engineer must be familiar. Estimating, power press work, drawing operations, determination of proper drawing operations, drawing presses, visualizing movements for estimating, and tool and die costs.

The remaining fourteen chapters are devoted to an analysis of power press operations, machining and assembling operations on fourteen different products. Numerous sketches and a great many curves are given. Calculations are shown step by step.

A careful study of this book should enable the reader to get a good idea of the methods and applications to be used in processing material.

Evaluation of Residual Stresses

K. HEINDLHOFER. 196 *pages*, 5 x 8 *in. Published by McGraw-Hill Book Co., Inc.*, 330 *W. 42nd St., New York* 18, *N. Y.* $4.

A well-known metallurgist has provided this material on the nature, detection, measurement and analysis of residual stress. It is a practical book to enable the student to use various recently invented instruments such as electric strain gages, to study residual stress, and to interpret the results with accuracy.

The first chapter is devoted to a study of the nature and significance of residual stress. To clarify the limitations of stress analysis as imposed by the nature of the material, the second chapter is devoted to the structure of metals, and the textures caused by various forming techniques. The significance of crystalline structure and the elastic properties of crystalline aggregates, homogeneities and other set factors causing a serious deviation in isotopes are explained.

Quantitative treatment of strain and stress and their interrelation in simple and complex combinations is explained

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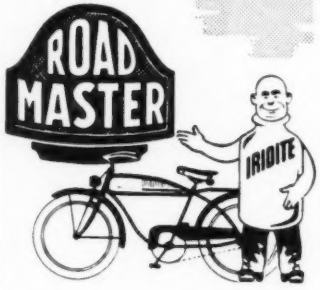

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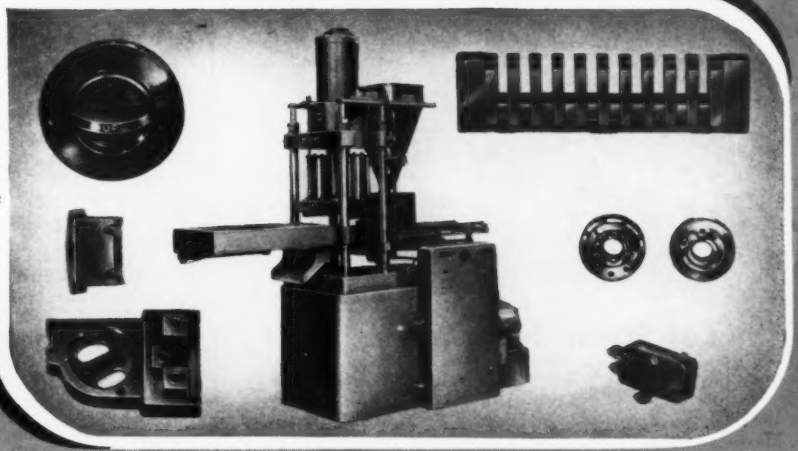
Large or small parts, simple or complex, a few or a million, can be economically molded on Stokes fully automatic plastics presses.



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in the third chapter. The fourth chapter describes the mapping of residual stresses, and introduces the latter part of the book which is devoted to the detection and measurement of residual stresses. Stress detection by the use of Mathars' method, by the evaluation of residual stress by sectioning according to Rosenthal and Norton, and X-ray diffraction methods are described. Residual stress determination by brittle coating is covered briefly. Chapter Six includes mechanical strain gages and X-ray diffraction techniques. Chapter Seven gives several examples of experimental stress analysis for the detection of residual stresses.

This little volume packs a great deal of useful information for one who wishes to get a good understanding of the nature and detection of residual stresses. The text includes references to many of the significant papers in this field.

Practical Considerations in Die Casting Design

Published by The New Jersey Zinc Co., 160 Front St., New York 7, N. Y. 246 pages 6 x 9 in. $3.

There have been so many generalizations made about die cast products and techniques that at times the design engineer must feel inclined to shy away from specifying this method of production, even though a competing method costs more, limits the rate of production, or requires additional finishing and assembling operations. He is told what not to do, but not in such practical terms that he can apply the information to his own specific problem.

For example, he is told that walls should be thick enough to resist the loads applied in service, yet thin enough so that material is not wasted in producing the part. But what are the recommended minimum and maximum limits? He is told that large variations in wall thicknesses may cause stress concentrations and breakage at the juncture of the two sections. But suppose that both heavy and thin walls are required in the part? What then?

In preparing the book "Practical Considerations in Die Casting Design" engineers of the New Jersey Zinc Co. were not satisfied with mere generalizations, and as a result have prepared a text that discusses the everyday problems encountered by the designer in practical and specific terms. Each chapter includes a discussion of such problems, sets up the advantages and limitations of different methods of solution, and shows by photographs and drawings what has been done by leading die casting manufacturers in

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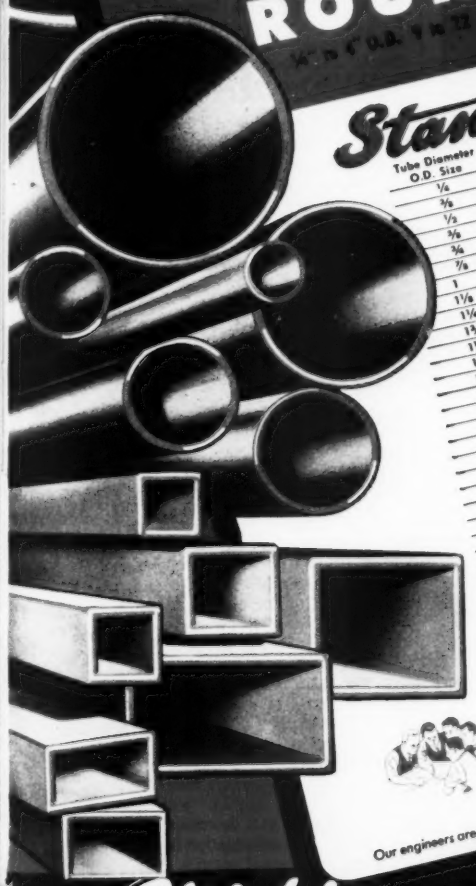
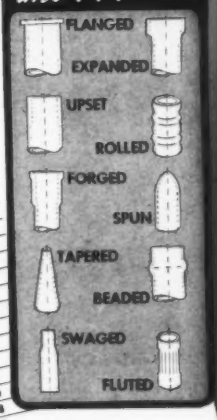


Standard Sizes

Tube Diameter O.D. Size	Maximum Wall BWG Gauge Decimal	Gauge	Minimum Wall BWG Gauge Decimal	Gauge
¼	.049	18	.028	22
⅜	.065	16	.022	24
½	.083	14	.022	24
⅝	.095	13	.022	24
¾	.095	13	.022	24
⅞	.095	13	.028	22
1	.095	13	.028	22
1⅛	.095	13	.028	22
1¼	.095	13	.028	22
1⅜	.095	11	.035	20
1½	.120	11	.035	20
1⅝	.120	11	.035	20
1¾	.120	11	.035	20
1⅞	.120	9	.035	20
2	.148	9	.035	20
2⅛	.148	9	.035	20
2¼	.148	11	.035	20
2⅜	.120	9	.035	20
2½	.148	11	.035	18
2⅝	.120	9	.049	18
2¾	.148	9	.049	18
2⅞	.148	9	.049	18
3	.148	9	.049	18
3⅛	.148	9	.049	18
3¼	.148	9	.049	16
3⅜	.148	9	.065	16
3½	.148	9	.065	16
3⅝	.148	9	.065	16
3¾	.148	9	.065	
3⅞	.148	9		
4	.148			

Can be BENT also . . .



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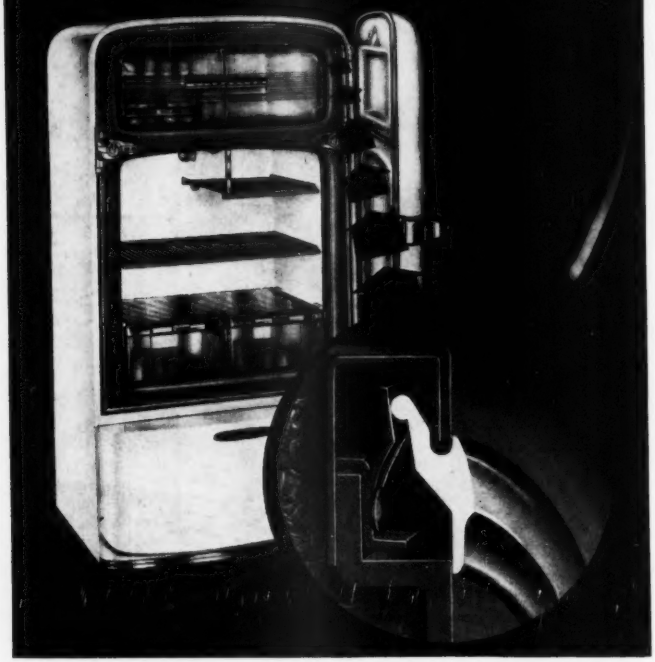

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the country. Consequently, the book is easily read, copiously illustrated, and packed with practical data for both the product designer and the tool designer.

The introduction, Chapter 1, is a review of the general considerations in the design of die casting. Chapter 2 is a discussion of section thickness. Other chapter headings are: Where Intricity Is An Asset; Ribs; Fins, Beads, and Bosses Add to Utility of Die Castings; Cores Are Assets in Die Castings; When to Use and When to Avoid Undercuts; Fillets and Edges; Wheels, Gears, and Cams; Where and Why Die Cast Threads Are Used; Fastening Expedients; Inserts in Relation to Die Casting Design; How Design Affects Flash Removal Cost; Piercing and Forming Possibilities; How Design Influences Polishing Costs; and Appearance Factors, Including Decorative Features and Lettering.

It is apparent that the book is an important supplement to the technical literature on die casting. While the designer may not find all the answers to all of his problems in this one volume (such a book would be impossible to write) he cannot help but obtain ideas that will aid him in solving most of them.

Handbook of Plastics

H. R. SIMONDS, A. J. WEITH *and* M. H. BIGELOW. *Second edition,* 9½ x 6½ *in.,* 1,511 *pages. Published by D. Van Nostrand Co., Inc.,* 250 *Fourth Ave., New York* 2, *N.Y.* $25.

The new edition of this handbook was made necessary by the many valuable developments of the war years that have been translated into commercial production. In fact, a comparison of this edition with the first edition would furnish an index to the rapid growth of the plastics industry. The full text of the new edition has been largely rewritten.

In this book, plastics are covered from raw materials to finished products, including details of the manufacturing methods for the raw materials, and the machines and processes that are used to fabricate the finished products. The plastic materials themselves are discussed thoroughly, with the specific properties that determine their applications. This information is given for all the commercial plastics, textile fibers, rubbers and elastomers, natural resins, films and sheetings, laminates and plywoods, coatings, adhesives and other related materials.

In addition, there are valuable sections on plastic patents, cost accounting in the plastics industry and the chemistry of plastics. There is a large

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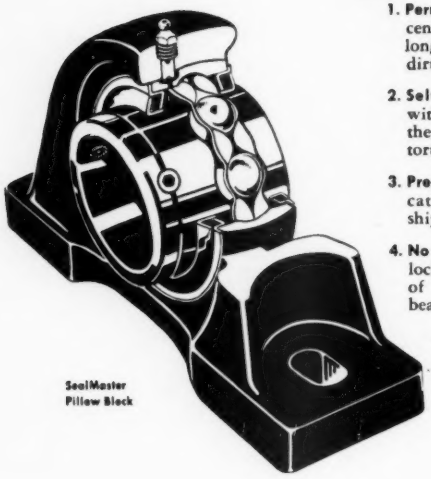

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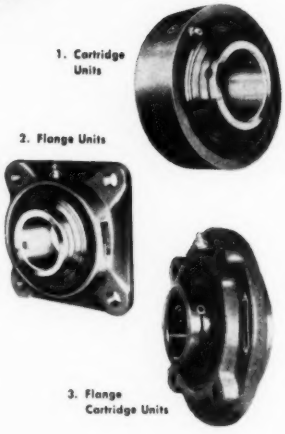

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What Good Are Standards?

ELEVEN AUTHORS. 48 *pages,* 8½ x 11 *in., paper covers. Published by American Standards Association, Inc.,* 70 *East Forty-fifth St., New York* 17, *N. Y. To nonmembers of ASA,* $1; *to members of ASA,* 75 cents.

Series of papers presented at the 1948 annual meeting of the American Standards Association. The discussions include: Legality of standardization; standardization work of the Munitions Board; the functions of standardization in purchasing, manufacturing, and marketing; and the importance of standardization to wholesalers, retailers, consumers and manufacturers.

The titles of papers, and their authors, included in the publication are:

Is Standardization legal?; by John F. Sonnett.

How the Munitions Board Is Coordinating Army, Navy, Air Force Standards; by W. John Kenney.

Is Standardization an Engineering, Purchasing or Production Function?, by W. P. Kliment.

Interrelation of Standardization and Purchasing Activities; by Arthur J. Beck.

Methods of Evaluating Savings from Standardization; by William Floyd.

Practical Answers to a Practical Question—What Good Are Standards?; by Earl O. Shreve.

What Good Are Standards in Specifying and Purchasing Manufacturing Materials?; by Vincent de P. Goubeau.

What Good Are Standards in Manufacturing?; by Harold L. Hoefman.

What Good Are Standards in Marketing?; by R. C. Sogge.

What Good Are Standards to Wholesalers and Retailers?; by Gerald C. McDonald.

What Good Are Standards to the Ultimate Consumer?; by Carol Willi Moffett.

Rocket Propulsion Elements

GEORGE P. SUTTON, *Supervisor, Propulsion Development North American Aviation, Inc.* 294 *pages,* 6 x 8½ *in. Published by John Wiley & Sons, Inc.,* 440 *Fourth Avenue., New York* 16, *N. Y.* $4.50.

This book was written to present the basic elements and technical problems of rocket propulsion and to describe the physical mechanisms and designs of rocket propulsion systems. Emphasis has been placed on the practical treatment of subject matter by including examples, illustrations and tablulated

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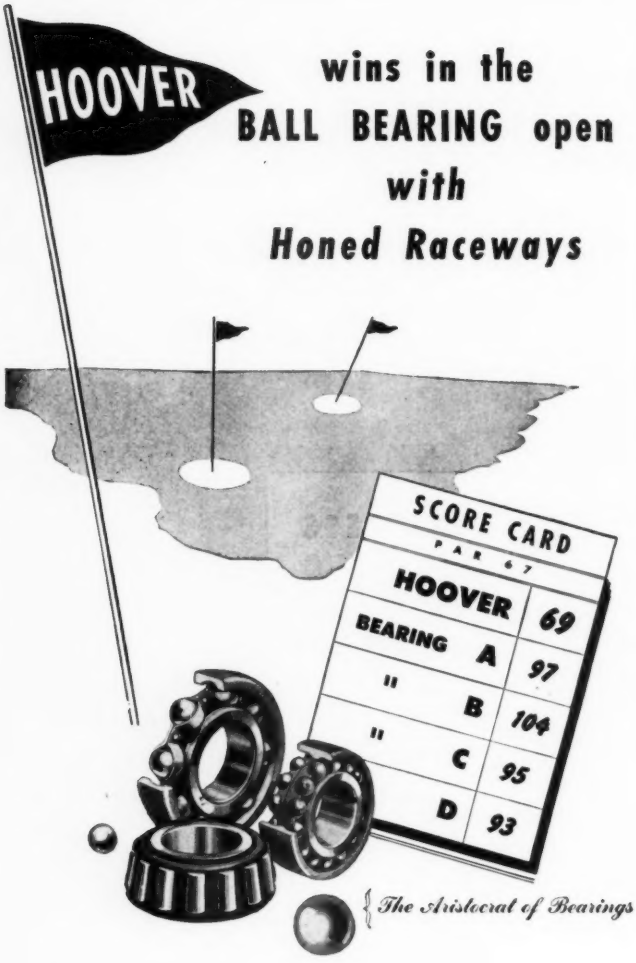

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data of current interest. National security restriction has limited the data presentable in such a work as this, but to most engineers it is believed that the included information is newly interpreted and applied.

A knowledge of elementary physics, chemistry, mechanics and thermodynamics is presupposed. Chapters are devoted to definitions, liquid rocket propellants, motors and feed systems, testing and solid propellant rockets. Greater stress is applied to liquid propellant rockets than to solid propellant units, but the thermodynamic, thermochemical and ballistic principles, as presented in Chapters 3, 4 and 8, apply to both types of propellants. A chapter is devoted to the history of rocket development from 13th century Chinese variety to the late American models. References for further study are given at the end of every chapter.

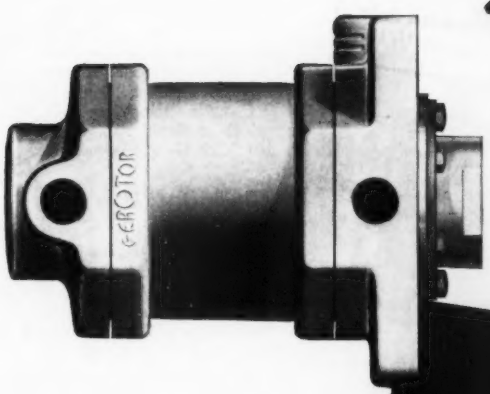
Introduction to Gas-Turbine and Jet Propulsion Design

C. A. NORMAN, *Professor of Machine Design, and* R. H. ZIMMERMAN, *Assistant Professor of Mechanical Engineering, both of Ohio State University. First edition.* 286 *pages,* 6 x 9 *in. Published by Harper & Bros. Publishers,* 49 *E.* 33*rd St., N.Y.* $5.

The authors realized that in writing this work they were offering information in book form upon a subject that is undergoing tempestuous development. This book has been composed strictly as an introduction to the design problems facing the future of jet-propulsion and gas turbine design. It is meant for students and for professional engineers who wish to further their knowledge in a field of science that is becoming more and more a part of their daily lives.

Although the subject of jet-propulsion lends itself to exploitation of the spectacular, the authors of this volume felt that scientific success rested on far firmer grounds than pulp-fiction entertainment. Consequently, they have presented engineering advancement in these fields as a series of design problems and solutions. Mathematical complexities have been avoided and material is presented in a simple and concrete manner. A knowledge of thermodynamics is the most important prerequisite.

Almost seventy-five percent of the book is devoted to the design of the various elements of a gas turbine. Combustion chambers, compressors, construction materials and general design considerations are explained and illustrated. Aircraft power plants are discussed with clarity, but of course, national security restrictions have lim-



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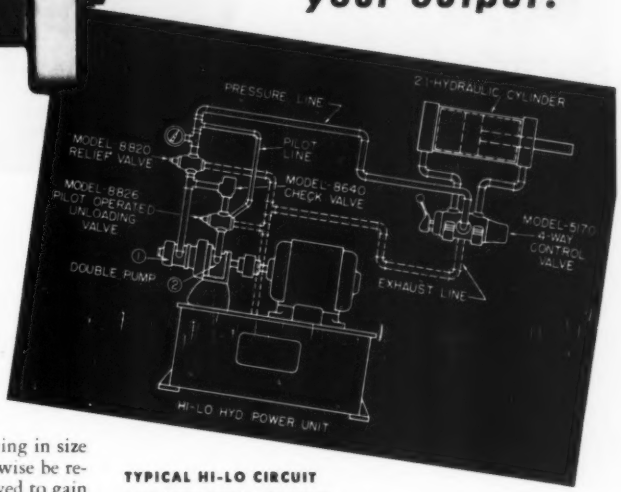

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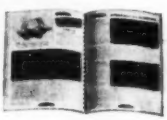

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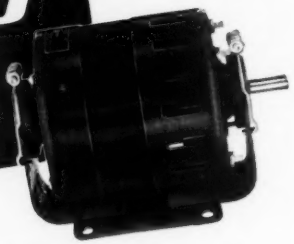

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Motion and Time Study

RALPH M. BARNES, *Professor of Industrial Engineering and Director of Personnel, College of Engineering, University of Iowa. Third Edition. 540 pages, 6 x 9¼ in. Published by John Wiley & Sons, Inc., Fourth Ave., New York 16, N.Y.* $5.

The third edition of the standard book by Dr. Barnes has been completely revised and five new chapters have been added. Shortly before publication of this edition, the author completed a survey of leading factories to determine the most successful motion and time study techniques and incorporated his findings into this text.

New material is included on the following topics: (1) process analysis, (2) gang process charts, (3) activity charts, (4) man and machine charts, (5) rating operator performance, (6) effect of practice, (7) motion and time study training programs.

An excellent picture of the scope of this book is given in Fig. 1, which is a pictorial outline of the contents. Major subjects covered are: (1) Finding the most economical method, (2) standardizing the operation, (3) determining the time standards, (4) training the operator. Under the first, three subjects are covered: (a) Process analysis, done by process chart, by flow diagrams and gang process charts; (b) equipment utilization, done with the activity charts and man and machine charts; (c) operation analysis, done with the operation chart and mico-motion study or simo-charts.

Under "Standardizing Operations," written standard practice is given.

"Determining the Time Standards," is covered by time studies, production studies and random check delay studies.

Standard data is given under elemental standard data and fundamental motion standard data. "Training the

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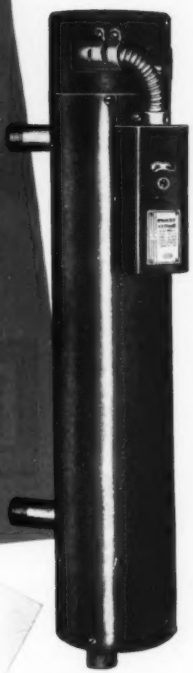

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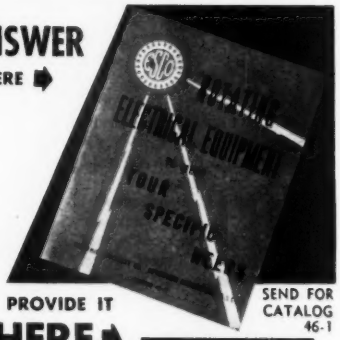

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The chapter on the preparing time study program is excellent, and the chapter on training the operator is very practical. The appendices include a preview of the work method program showing the method of presentation, whether by demonstration, slides or charts or motion pictures, and giving references including page designations. A similar complete training program is also given in another appendix. Sixty-eight problems for students are given in the back of the book, and an eight-page bibliography is included. There can be no doubt that the author has done a very thorough, comprehensive and practical job on this subject.

Jigs and Fixtures

FRED H. COLVIN, *Editor Emeritus of* AMERICAN MACHINIST, *and* LUCIAN L. HAAS. *Fifth Edition.* 404 *pages,* 6 x 9¼ *in. Published by McGraw-Hill Book Co., Inc.* 330 *W.* 42*nd St., New York* 18, *N. Y.* $4.50

This is the latest revision of this standard guide covering the various aspects of design and use of jigs and fixtures. It brings standard data up to date and adds new standards and new ideas on airplane fixtures, fixtures for mass production, and on special fixtures for railway shops.

The text is divided into six sections. These are: Standardizing fixture design; details in fixture design; accuracy of drills; methods for production; handling large assemblies; and toolroom fixtures. Many types of jigs and fixtures are shown in actual use and suggestions are given for various fixture problems.

Principles of Physics—III—Optics

FRANCES W. SEARS, *Professor of Physics, Massachusetts Institute of Technology, Third Edition, revised.* 369 *pages* 6 x 9 *in. Published by Addison-Wesley Press Inc., Cambridge* 42, *Mass.* $6.

This volume was designed as a physics textbook for engineers and students of engineering. It includes descriptive, pictorial and mathematical explanations for the basic optical phenomena, and presents problems of physics from the standpoint of engineering practicality.

A number of changes have been made in this edition. The order of presentation in the chapter on lenses has been rearranged so that, without sacrificing generality of approach, a detailed discussion of thick lenses can be omitted if desired. The chapters on physical optics have been largely

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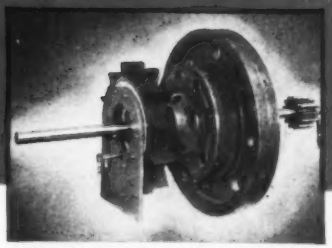
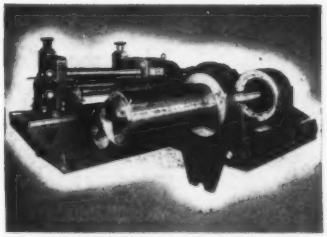
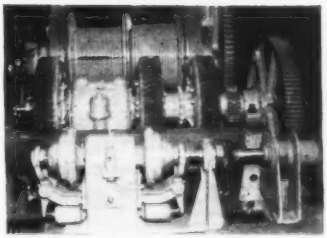


Fawick Airflex Clutch and Fawick Air-Ring Brake conversion for Bliss Model 6C Press.



Dual Fawick Air-Ring element used as Slip Clutch on Heavy Duty Strip Winder by Steel Equipment Co., Cleveland, Ohio.



3 Fawick Air-Ring elements used for Swing and Crowd Retract Clutches on Marion Type 362 by Marion Power Shovel Co., Marion, O.

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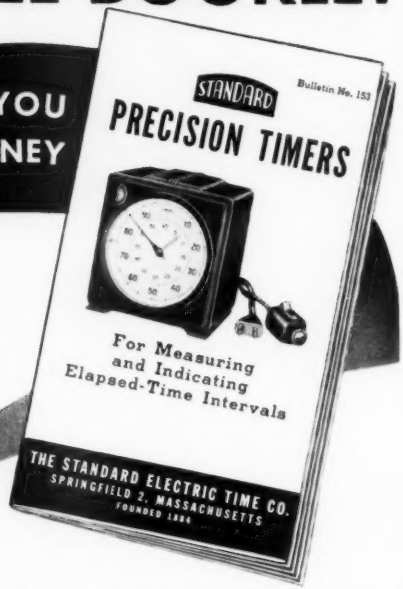

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rewritten. The limit of resolution of an optical instrument has been given a more unified treatment, and the letter symbols have revised to accord with current practice.

The fourteen chapters form a systematic course of study ranging from the nature and propagation of light to an explanation of the "science of color". Intervening chapters discuss such subjects as polarization, interference, diffraction, photometry and thermal radiation.

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Quality Control in Industry

JOHN G. RUTHERFORD. *First Edition.* 197 *pages,* 5¾ x 9¼ *in. Published by Pitman Publishing Corp., New York, N. Y.* $3.50.

The author believes that there is a need for a text showing how to apply the general principles of quality control through an organizational setup, as well as how to use specific statistical techniques themselves. This book will give the man with little industrial quality control experience an overall picture of the functions of a quality control division or department, as well as simplified information and data on the various statistical methods.

The first part of the book is devoted to the organization of the quality control department. It includes the economics, the determination of economical quality control, the quality control department costs, reports and records, and the personnel training.

The principles of statistical methods are explained in the following sections: Inspection, process control, and specialized applications. Each have been given in theory and detailed procedure. A final chapter discusses the practical applications of statistical methods. The author also points out the problems and potential troubles in operating a quality control program in an industry.

Power System Stability

EDWARD W. KIMBARK, *Professor of Electrical Engineering, Northwestern University. Volume I.* 355 *pages,* 5¼ x 8¼ *in. Published by John Wiley & Sons, Inc., Fourth Avenue, New York* 16, *N. Y.* $6.

This is the first of three volumes treating the subject of stability of alternating current electric power systems. It covers the elements of the stability problem, the principal factors affecting stability, the ordinary

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simplified methods of making stability calculations and illustrations of the application of these methods in studies which have been made on actual power circuits.

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This treatise should prove useful not only to readers seeking an understanding of power system stability but also to those desiring information on related topics. Such topics include a-c calculating boards, fault studies, circuit breakers, protective relaying, synchronous machine theory, exciters and voltage regulators, and the solution of non-linear differential equations.

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Radio Fundamentals

ARTHUR L. ALBERT, *Professor of Communication Engineering, Oregon State College.* 595 *pages,* 6 x 9 *in. Published by McGraw-Hill Book Co., Inc.* 330 *W.* 42*nd St., New York* 18, *N. Y.* $4.50.

Covering the basic acoustical and electrical principles of radio, this book is intended primarily for students who are non-electrical majors. An engineer with some training in elementary electrical theory will find the text helpful in understanding the broad field of radio, including the most recent developments.

The major topics treated are acoustics, radio circuits, transmission lines and cables, vacuum tubes, rectifiers, amplifiers, oscillators, amplitude and frequency modulation and detection, transmitters, receivers, and antennas. Ample coverage is given to television practice and theory. For review, several chapters are devoted to the basic electrical theories of greatest importance in the study of radio. Numerous applications of the fundamentals are included to illustrate the lessons under discussion. A summary, review questions and problems follow each chapter.

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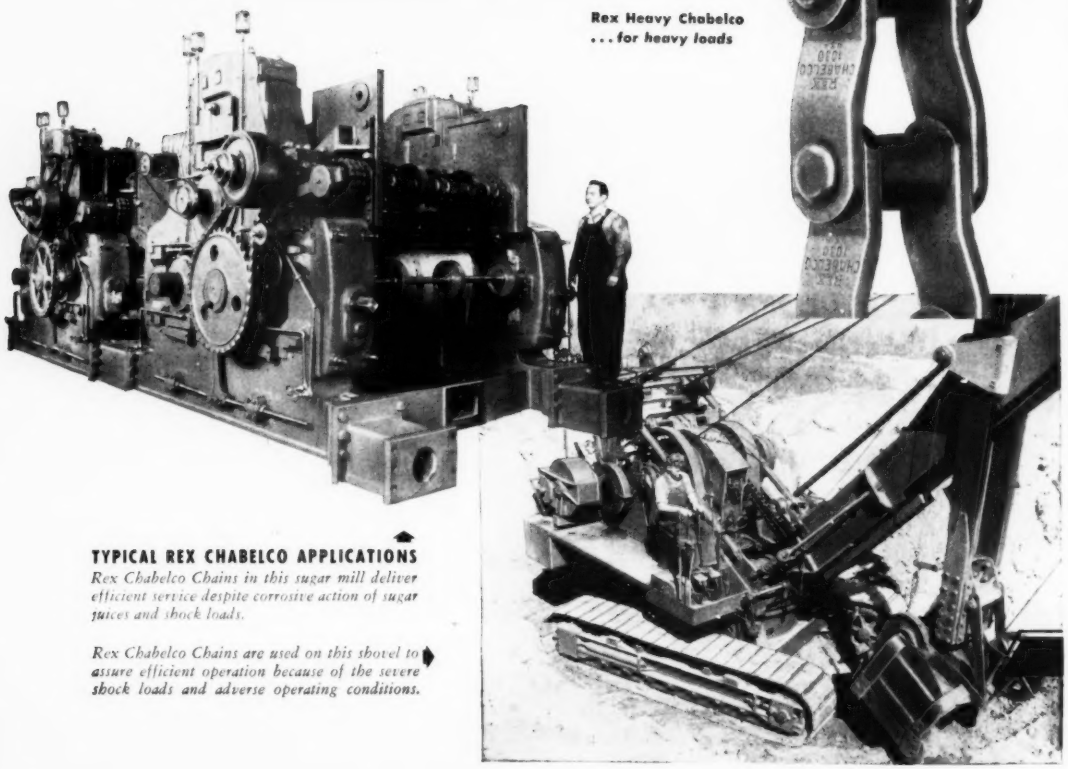

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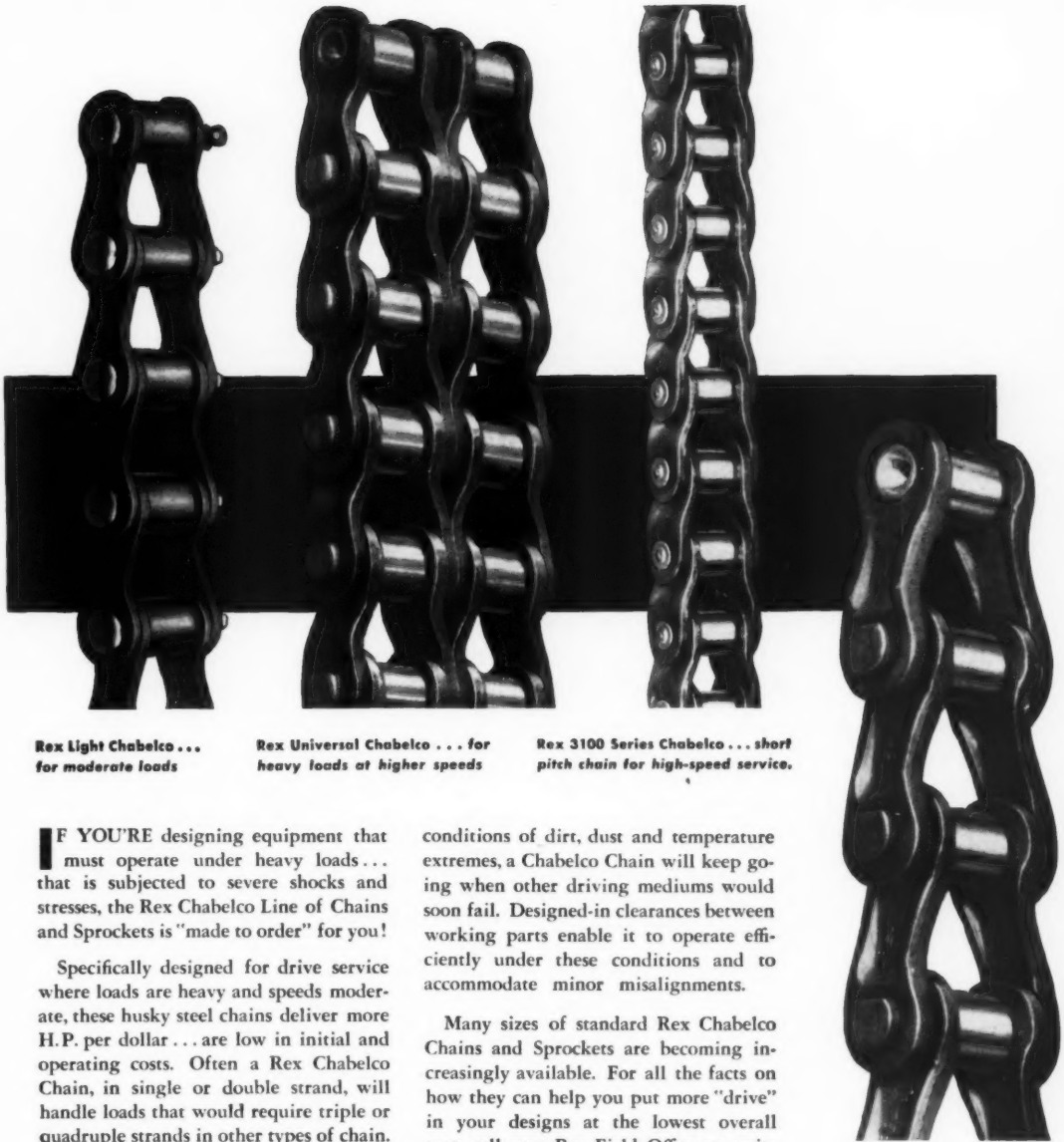

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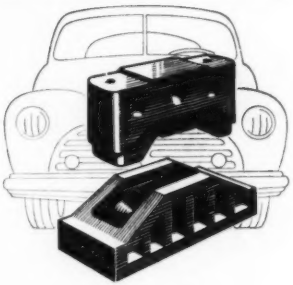

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The Election of November 2, 1948 GAVE NO MANDATE FOR SOCIALISM

The President and those who support his legislative program have objected to the substance of my previous editorial, which appeared under this headline: "Now is the Time to FIGHT SOCIALISM in Washington."

In that editorial I explained how Washington is poised to follow the disastrous policy of forcing industry to skimp on new plants and new equipment. That policy landed Britain in the numbing embrace of the Socialists. I cited the experience of Britain to show how such skimping on industrial tools can bring a nation to economic stagnation . . . and Socialism.

The President, in his recent Jackson Day speech, brushed aside this warning . . . "They are again trying to frighten the people with the old worn-out bugaboo that Socialism is taking over in Washington." Senator Francis J. Myers of Pennsylvania asserted that I was guilty of "warfare against any reasonable effort to keep our system of free enterprise working."

These criticisms may be sincere. But they are not well-founded.

I want to show why they are not well-founded by basing this editorial on Washington rather than Britain.

In Washington the Administration has proposed a legislative program, the key parts of which would clearly put the country far on the road to Socialism. Let us see how.

There are two steps in the process:

FIRST: The government by its taxation program undermines private industry so that it cannot provide itself with the necessary new plant and tools.

SECOND: The government itself steps in to provide the plants and equipment that it has blocked industry from getting. *That is Socialism.*

Here is how Washington is promoting Socialization of the steel industry—and of other industries.

Steel has been expanding its capacity and improving its equipment chiefly by plowing back its profits. During the last three years it has spent $1.4 billion for new plants and new tools. That was more than the companies had available from their own earnings. But profits provided more

continued on next page

than half of that money—more than $700 million. The remainder came from loans and from depreciation reserves set aside out of the earnings to replace worn-out equipment.

Profits must continue to provide the funds needed to pay for the bulk of the steel industry's necessary expansion. That is because private citizens, their income slashed by heavy taxes, have not been willing to buy steel stocks even at prices ruinously low for the companies and their present stockholders. The stock market currently prices the mills and other facilities of the nation's principal steel-producing companies at far less than fifty percent of the cost of reproducing them.

Let us take another example. Profits are essential to expansion in the electric light and power industry also. This year private companies are planning to buy $2 billion worth of new plant and equipment. To do that without going overboard in debt, they must sell to the public some $300 million worth of common stock. A squeeze on their profits would make that sale virtually impossible.

For tens of thousands of small business enterprises profits afford virtually the only practical source of funds for new equipment and expansion.

In the face of these and many other examples that might be cited, what is the most effective way to prevent industry from re-equipping itself and expanding is capacity to meet our essential needs?

Obviously, it is to cut down profits. And that is what the Administration is trying to do. The President has declared that steel prices are too high, and is demanding that Congress raise taxes sharply on all corporations.

There you have the first step toward socializing industry.

Next comes step two. Have the government supply the tools and equipment which, by taxation, it prevents industry from getting.

The Administration has proposed legislation to carry out this second step. It is called the "Economic Stability Act of 1949," for short, the "Spence Bill."

This bill gives the President the power to provide industrial facilities—in steel, power or any other industry—where he finds that a shortage is hampering or is likely to hamper the economy.

True, the bill says that the government is not to construct new plants if private companies will do it through government loans, on terms prescribed by the President. That may be just one step short of complete socialization. But it is only a short step. And the Spence Bill authorizes the government to take that step.

By itself, the Administration's "Stability Act" sounds harmless enough. It would have the government build plants only as a last resort. But it provides also that if private enterprise cannot turn out all the goods the country needs, the government can and should step in and provide the equipment to do it.

Now, take that power together with an Administration tax program that undercuts the ability of private enterprise to supply the new plants and equipment it needs out of its own earnings. That combination promotes government ownership and operation of industry.

And that is Socialism.

The American people, of course, have the right to live under any system they choose—Capitalism, Socialism, Fascism, Communism, or what-have-you. But before Socialism or any other "ism" is imposed upon us from above, the people should know the facts. If this editorial shall have contributed in some small degree to that end it will have served its purpose.

The election of November 2, 1948 gave no mandate for Socialism.

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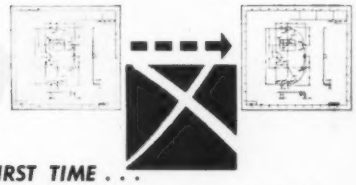

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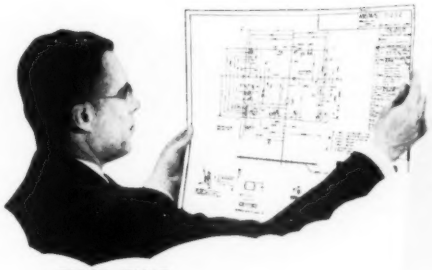

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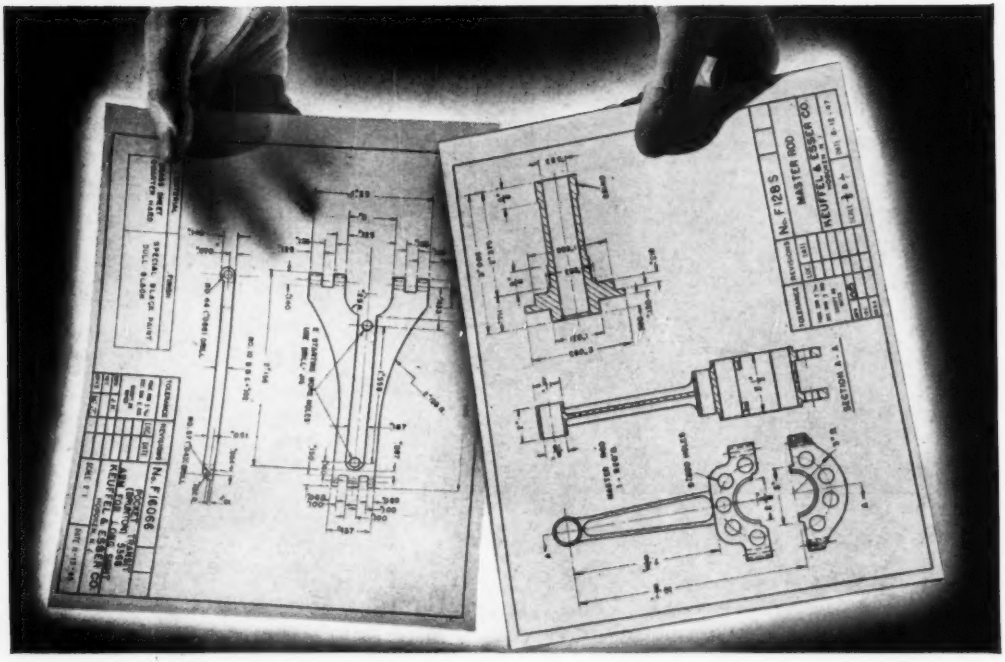

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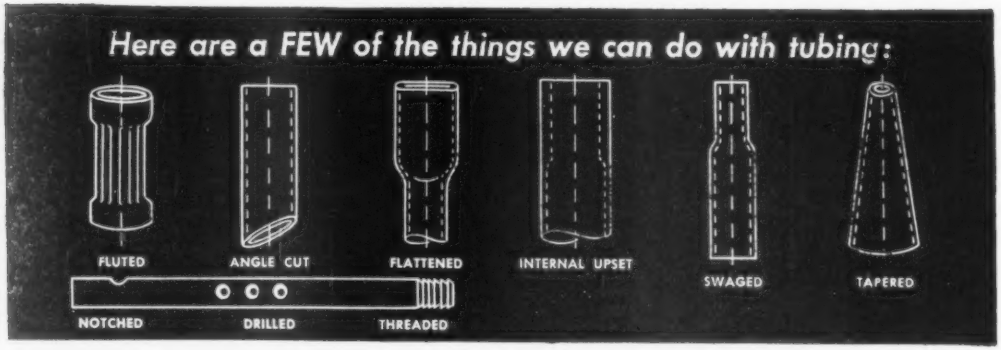

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...provides volumetric efficiencies up to 97%!...provides torque efficiencies up to 90%!
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This booklet explains PRESSURE LOADING . . . write for your copy today.

Pressure Loading is a Pesco patented principle of hydraulic pump design which utilizes pressure from the discharge of the pump to maintain a minimum end clearance between gear and bearing faces. This automatically compensates for wear.

Pesco hydraulic pumps with *Pressure Loading* will not "freeze" under normal load conditions. They have an unusually long service life. They require minimum maintenance. Do not require micrometer fits. They guarantee highest possible efficiencies under all operating conditions.

Only Pesco hydraulic pumps have *Pressure Loading*. If the design of your product calls for the use of hydraulic pumps . . . or other hydraulic equipment . . . it will pay you to send for your copy of the free booklet, "Pressure Loading by Pesco".

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1. Provides uniform rate of fluid flow regardless of variations in load, in viscosity of hydraulic fluid, or in temperature.
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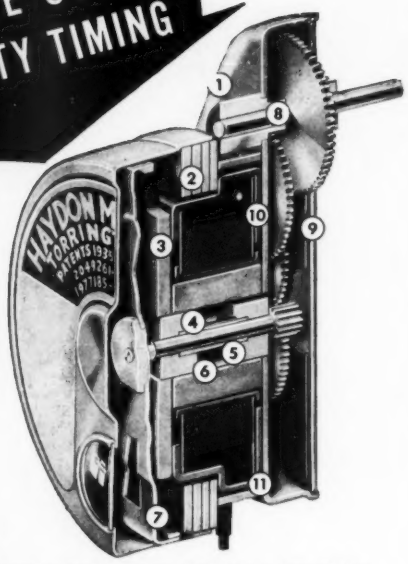

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1. *Compact, sealed gear housing.*
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7. *Uniform reluctance ring rotor for uniform torque characteristics, rigidly held by spunover support.*
8. *Double bronze bearing on output shaft.*
9. *Lubricant carried by capillary attraction to each gear assembly individually, irrespective of mounting position of unit.*
10. *Protection against voltage surges with fold of insulation.*
11. *Projection-welded field assures accurate air gap and rugged construction.*

Comprehensive range of output speeds makes Haydon motors universally adaptable. Many speeds available from stock in standard models. Write for our new Engineering Catalog covering all Haydon's motors and timers. For an actual timing motor demonstration at your desk, request a call by your Haydon representative.

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So now, when you are probably concentrating on redesigning *your* products to sell successfully in competitive markets, we think you'll want as much help as we can give you in *Designing for Lower Costs.*

The June issue of PRODUCT ENGINEERING will be completely devoted to this very important subject. Watch for it. This issue seems sure to set a new high mark in industrial publishing.

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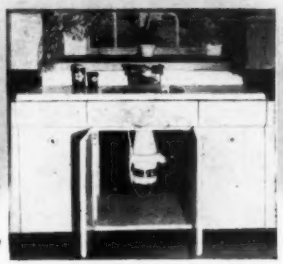
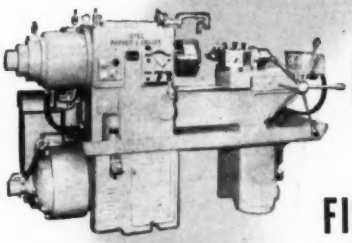
PRODUCT ENGINEERING for JUNE...

Designing for Lower Costs

One important thing in common



A *FIBERGLAS*-insulated motor in the "EUREKA Dispos-O-Matic" helps provide housewives with a dependable, time-saving waste food disposer. Product of: Eureka Williams Corporation, Bloomington, Ill.



A *FIBERGLAS*-insulated main drive motor on this "Electro-Cycle" turret lathe permits increased reversal capacity not possible with organic insulating materials. Product of: Warner & Swasey, Cleveland, Ohio.

A FIBERGLAS*-INSULATED ELECTRIC MOTOR

A *FIBERGLAS*-insulated motor in this "Precise 40" hand tool makes it possible to increase power from 1/7 HP to 1/5 HP without increasing the size of the motor frame. Product of: Precise Products Company, Racine, Wisconsin.

FIBERGLAS-insulated motor on the "LeTourneau Tournapull" loads, steers, turns and empties these giant earth movers. Motor dependability is important because they're operated under the toughest weather conditions. Product of: R. G. LeTourneau Inc., Peoria, Ill.

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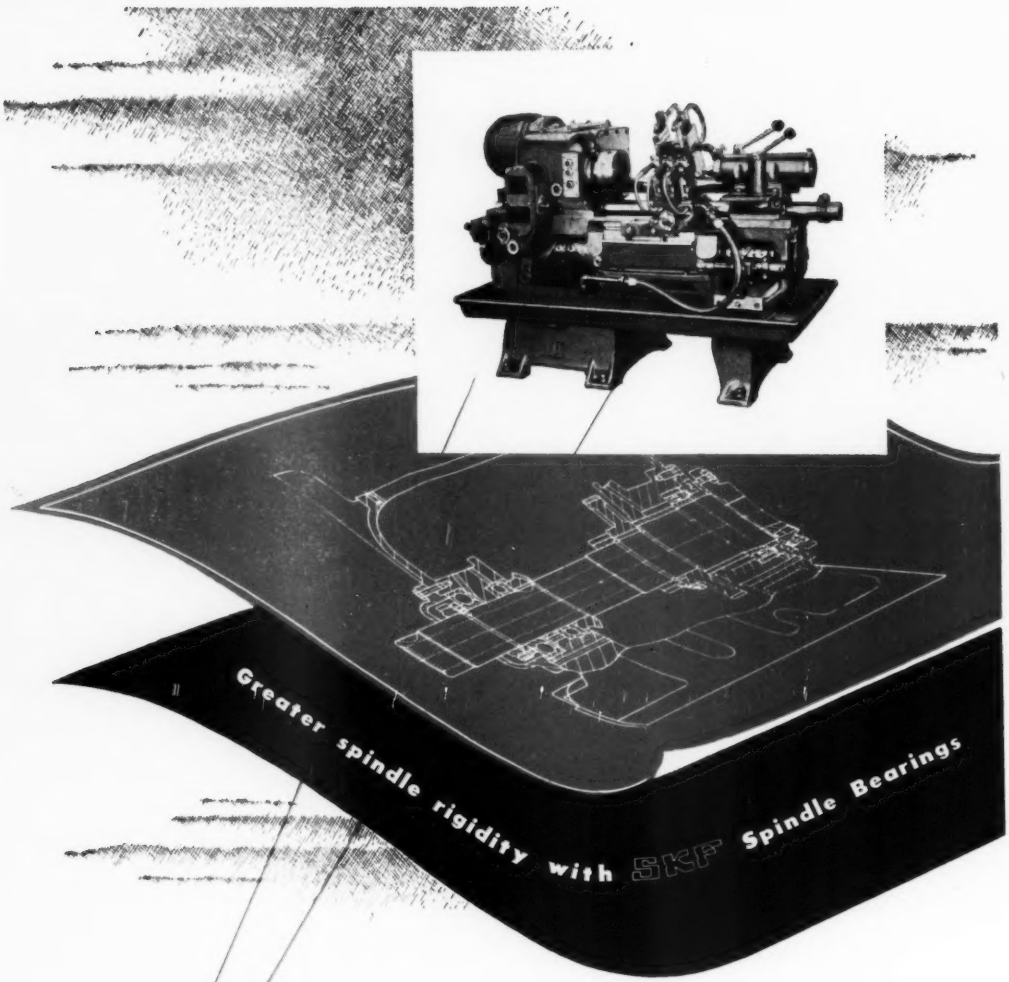

A couple ten-thousandths play . . . radial or end . . . can be the difference between "Reject" and "OK". That's why Jones & Lamson wanted a spindle design that was as rigid as possible.

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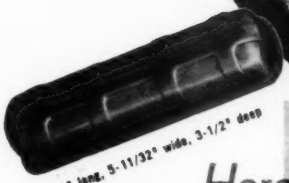

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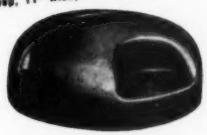

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(1) CARBON BRUSHES—U. S. Graphite Co., Saginaw, Mich. Catalog, 40 pages. Illustrated brochure listing sizes, types, and materials used in carbon brushes for electrical machinery, contains information on brush characteristics and recommended use for various grade brushes.

(2) ADJUSTABLE SPEED DRIVE—Reliance Electric & Engineering Co., 1076 Ivanhoe Rd., Cleveland 10, Ohio. Catalog, 45 pages. Graphically describes V-S, all-electric, adjustable speed transmission, operating from a-c circuits, and shows applications and selection data for V-S drives used on rotating systems.

(3) ELECTRICAL SWITCHES—W. L. Maxson Corp., Unimax Switch Div., 460 W. 34th St., New York 1, N. Y. Catalog, 30 pages. Contains specifications and designs to aid in switch selection, plus a new section on KMX type switches.

(4) SILICONE RUBBER—General Electric Co., Chemical Dept., Pittsfield, Mass. Bulletin CDP-584, 24 pages. Devoted to heat resistant, mechanical and chemical resistant properties of silicone rubber.

(5) LIQUID HANDLING PUMPS—Marlow Pumps, Ridgewood, N. J. Bulletin PM48, 12 pages. Presents information on new type of centrifugal pump for handling petroleum and volatile liquids, and shows 10 charts to aid selection and installation.

(6) SPEED MEASUREMENT—James G. Biddle Co., 1316 Arch St., Philadelphia 7, Pa. Sketches description and operation of resonant reed tachometers, frequency meters, rate-of-vibration indicators, hand tachometers and other speed measuring instruments.

(7) AIR CONTROL VALVES — Ross Operating Valve Co., 120 Golden Gate Ave., Detroit 3, Mich. Bulletin 301, 12 pages. Describes and diagrams three-way and straight-way solenoid valves, and gives applications for use with water and air pressures.

(8) MATERIAL SPECIFICATIONS — Heli-Coil Corp., 47-22 35th St., Long Island City 1, N. Y. Data sheets, 4 pages. Gives SAE specification data on AMS-7245 and AMS-7247 aeronautical materials which are steel and bronze thread form inserts.

(9) MAGNETIC DRUM SEPARATORS—Eriez Mfg. Co., 627 E. 12th St., Erie, Pa. Bulletin 601, 4 pages. Relates the operation and applications for self-energized magnetic drum separators for the removal of ferrous material.

(10) STEEL TUBING—Joseph T. Ryerson & Son, Inc., Box 8000-A, Chicago 80, Ill. Brochure, 12 pages. Points out heat treatment, fabrication and application for tubing to replace solid bars for machine parts, and gives reference data to aid selection.

(11) EXTRUDED ALUMINUM— Light Metals Corp., Grand Rapids, Mich. Folder, 6 pages. Sketches various shapes, applications and plant facilities for producing extruded aluminum.

(12) DIFFERENTIAL SPEED REDUCERS—Winfield H. Smith Corp., Springville, Erie County, N. Y. Bulletin, 4 pages. Depicts design features of speed reducers with planetary elements.

(13) ELECTRIC MOTOR CONTROLS—Furnas Electric Co., Batavia, Ill. Bulletin 4201A, 12 pages. Presents pictures and description of 24 different mechanisms for electric motor control.

(14) CONTROLLED HUMIDIFICATION—Armstrong Machine Works, Three Rivers, Mich. Bulletin 1771, 12 pages. Offers information on steam humidifiers for automatically controlling relative humidity in laboratory and processing work.

(15) SEMI-CLOSED MOTORS — U. S. Electrical Motors Inc., Milford, Conn. Leaflet, 4 pages. Pictures and relates ventilation features of the Uniclosed sanitary motors.

(16) PILLOW BLOCK—Charles A. Colgate Co., 54 Vernon Drive, Pittsburgh 16, Pa. Bulletin 15, 4 pages. Gives specification and load rating tables, plus description of pillow block with self-aligning roller bearings.

(17) PRE-PLATED METALS—American Nickeloid Co., Peru, Ill. Bulletin, 4 pages. Contains 12 metal samples, all with different protective finishes and pattern effects, along with tables to aid selection.

(18) STRENGTH CALCULATIONS — Mechanite Metal Corp., Pershing Bldg., New Rochelle, N. Y. Bulletin No. 26 and Supplement, 22 pages. The first bulletin gives formulas for computing maximum stresses and deflections in circular flat plates cast in Mechanite. The supplement presents typical examples of the application of these formulas.

(19) CENTRIFUGAL PUMPS — Goulds Pumps Inc., Seneca Falls, N. Y. Bulletin 622 sheet A-3, 8 pages. Presents information on construction and specifications, plus performance and selection tables for centrifugal pumps.

(20) SELF-SEALING COUPLING—Aeroquip Corp., Jackson, Mich. Bulletin 100A, 4 pages. Describes, illustrates and gives specifications of new hydraulic coupling which can be disconnected without draining pressure lines.

(21) STEEL FORGINGS—Steel Improvement and Forge Co., 969 E. 64th St., Cleveland 14, Ohio. Booklet, 44 pages. Describes types and characteristics of forgings, forging production processes,

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heat treating procedures, machining of forgings and inspection methods. Tables present information on properties and applications of commercial forging metals.

(22) INDUSTRIAL BEARINGS — Johnson Bronze Co., New Castle, Pa. Catalog, 84 page. Contains specifications and illustrations for general purpose, graphite-bronze, ledaloyl self-oiling, and electric motor bearings, plus information about round, hexagonal and cored bars.

(23) FLUID DRIVE MOTORS—American Blower Corp., Detroit 32, Mich. Bulletin 3519, 4 pages. Gives specifications and operational information concerning new electric motors with built-in hydraulic transmission.

(24) THERMOMETERS—W. C. Dillon & Co. Inc., 5410 W. Harrison St., Chicago 44, Ill. Bulletin J, 4 pages. Illustrates and gives size specifications of 4 different models of stainless steel, expansion type thermometers.

(25) COPPERS AND COPPER ALLOYS —The American Brass Co., Waterbury 88, Conn. Publication B-34 Second Edition, 28 pages. Lists company's most generally used alloys, together with applicable specifications, such as grade, type, temper and anneal.

(26) WIRE CLOTH—Reynolds Wire Co., Dixon, Ill. Catalog B, 40 pages. Offers illustrated descriptions of 7 weaves and 27 mesh sizes along with discussion of various metals and protective coatings used in fabrication.

(27) INDUSTRIAL TUBING—The Ohio Seamless Tubing Co., Shelby, Ohio. Brochure, 12 page. Shows applications manufacture and sizes of mechanical seamless, aircraft seamless, electric resistant welded, forged and fabricated tubing.

(28) ROTARY BLOWERS — Roots-Connersville Blower Corp., 900 W. Mount St., Connersville, Ind. Bulletin 23-32-B-12, 16 pages. Presents information with cross-sectional views of four standard type blowers, a discussion of blower gears, recommended accessories and typical applications.

(29) SHADED POLE MOTORS — Victor Electric Products Inc., Cincinnati 9, Ohio. Gives characteristics and dimensions of M and K series motors in 200, 300 and 400 frame sizes.

(30) MERCURY SWITCHES—Minneapolis-Honeywell Regulator Co., 2753 4th Ave., South, Minneapolis 8, Minn. Catalog, 14 pages. Shows applications, production methods and tables to aid in selection from a line of 40 different models.

(31) INDUSTRIAL CONTRACTORS — Essex Wire Corp., R-B-M Div., Logansport, Ind., Bulletin 600, 8 pages. Presents specification tables for reversing and non-reversing a-c industrial contactors as well as descriptions and illustrations of various models.

(32) ELECTRIC FURNACES — C. I. Haynes, Inc., 113 Baker St., Providence, R. I., Catalog 110, 32 pages. Provides information on control of furnace temperatures for various heat treating processes, illustrates many furnace designs, and shows atmosphere tables for typical steels.

(33) FAN-COOLED MOTORS — Allis-Chalmers Leaflet, 4 pages. Describes line of totally enclosed fan-cooled motors in ratings from 150 hp to several thousand hp. Ventilating design has nest of tubes in stator frame which acts as heat exchanger.

(34) TUBULAR RIVET CHAIN—General Chain Co., 276 Lafayette St., New York 12, N. Y., Brochure, 4 pages. Illustrates the construction of hollow link chain which can be adapted for conveyor and drive purposes. Attachments placed in tubular rivets makes this chain remarkably adaptable.

(35) TEMPERATURE INSTRUMENTS—Leeds & Northrup Co., 4924 Stenton Ave., Philadelphia 44, Pa., Catalog ND4-23451, 35 pages. Describes and pictures instruments for measuring temperatures of generators, motors, condensers, transformers and other electrical equipment.

(36) VARIABLE SPEED MOTORS — U. S. Electrical Motors Inc., Milford, Conn., Catalog, 16 pages. Illustrated description of construction and operation of Varidrive motors with sliding spline drive.

(37) GEAR COUPLING—John Waldron Corp., New Brunswick, N. J., Catalog 57A, 8 pages. Presents information on design and application of gear coupling to provide for misalignment of machine shafts.

(38) ALUMINUM ALLOY GUIDE — Whitehead Metal Products Co., Inc., 302 W. 10th St., New York 14, N. Y., Leaflet, 4 pages. Shows properties, available forms and typical uses for 11 different aluminum alloys.

(39) NEW BALL BEARINGS—Norma-Hoffmann Bearings Corp., Stamford, Conn., Catalog, 24 pages. Describes applications for "cartridge" ball bearings, and gives dimensional data, load ratings, and performance characteristics.

(40) AIR CYLINDERS — Gerotor May Corp., Baltimore 2, Md. Catalog sect. 53, 16 pages. Entire line of Gerotor air cylinders is illustrated and described. Section is devoted to recommended applications for air equipment in typical installations.

(41) PUMP EQUIPMENT—Worthington Pump and Machinery Corp., Harrison, N. J. Bulletin W-350-B5B, 6 pages. Gives information on gate valves, needle valves, screw machine products, and centrifugally cast tubes.

(42) STAINLESS STEEL — Whitehead Metal Products Co., Inc., 302 W. 10th St., New York 14, N. Y. Booklet, 15 pages. Gives tables, graphs and illustrations showing chemical compositions, weights, bursting pressures, size selection, welding and screw type fittings of stainless steel.

(43) TELEVISION PARTS—Transvision Inc., 460 North Ave., New Rochelle, N. Y. Folder P-1, 4 pages. Gives descriptions and specifications of 19 component parts analyzed according to function, general use, ratings and connections.

(44) COMPONENTS OF QUALITY — Connecticut Telephone and Electric, Meriden, Conn. Catalog, 18 pages. Announces company's facilities for the production of electrical equipment.

(45) PRODUCTION CONTROL—Reeves Pulley Co., Columbus, Ind. Bulletin GN-487, 16 pages. Discusses the functions of automatic production control and the means of applying it to production machinery by use of variable speed transmissions and other controls.

(46) ENGINE GOVERNORS—The Pierce Governor Co., Inc., Anderson, Ind. Bulletin, 8 pages. Contains reference material with charts concerning governor operation and installation on engines.

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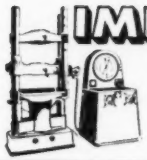
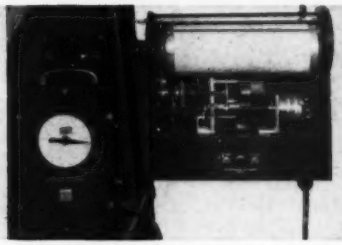


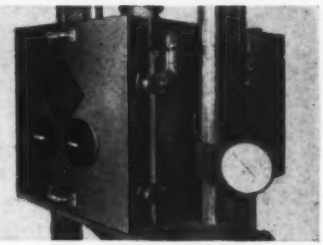
IMPORTANT -to testing machine owners

These accessories will broaden the usefulness—increase the value—of your present equipment

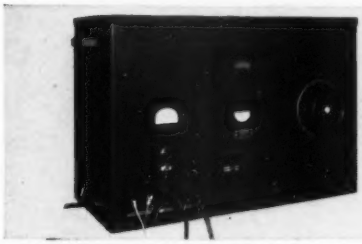
✓ Tate-Emery Air Cell extends precision range of testing machine downward to as little as 2 pounds, full scale. Portable or built-in indicator. Bulletin No. 264.



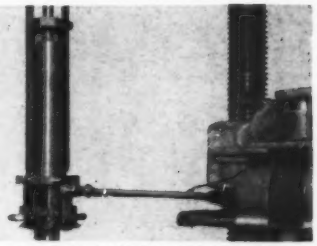
✓ Baldwin Strain Pacer permits maintenance of a constant rate of displacement between specimen gage points, rather than a constant rate of crosshead separation. Bulletin No. 289.



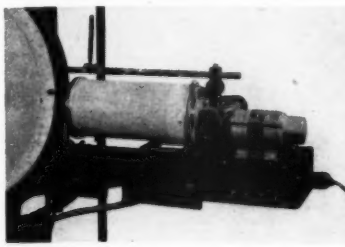
✓ Baldwin Controlled-Temperature Cabinet machine permits tension, compression and flexure tests at temperatures from —70° F to +200° F, maintained within ±1°. Bulletin No. 284.



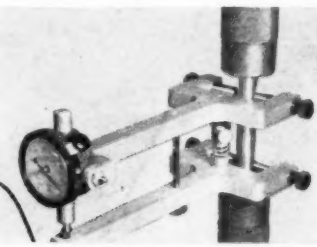
✓ Furnace and Control Panel for high-temperature testing, provide temperatures up to 1800°F (up to 2000°F on special order). Temperature uniformity up to ±3° is readily obtainable, and maintenance within 1° is not uncommon. Bulletin No. 261A.



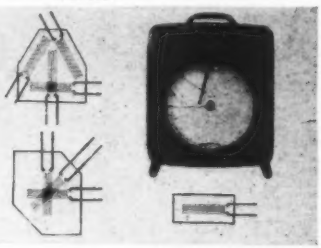
✓ Baldwin PSH-8 extensometer (microformer model PSH-8M), for use with standard threaded-end specimens at temperatures up to 1600° F. Bulletin No. 262.



✓ Baldwin Stress-Strain Recorders. Models available for virtually all common makes of testing machines. Bulletin No. 262.



✓ H. F. Moore indicating extensometer accommodates round or flat specimens up to 8 inches in length. Bulletin No. 263.



✓ Baldwin *SR-4 Strain Gages and other associated equipment have become an invaluable tool in stress analysis.

*Trade-Mark Registered U. S. Pat. Off.

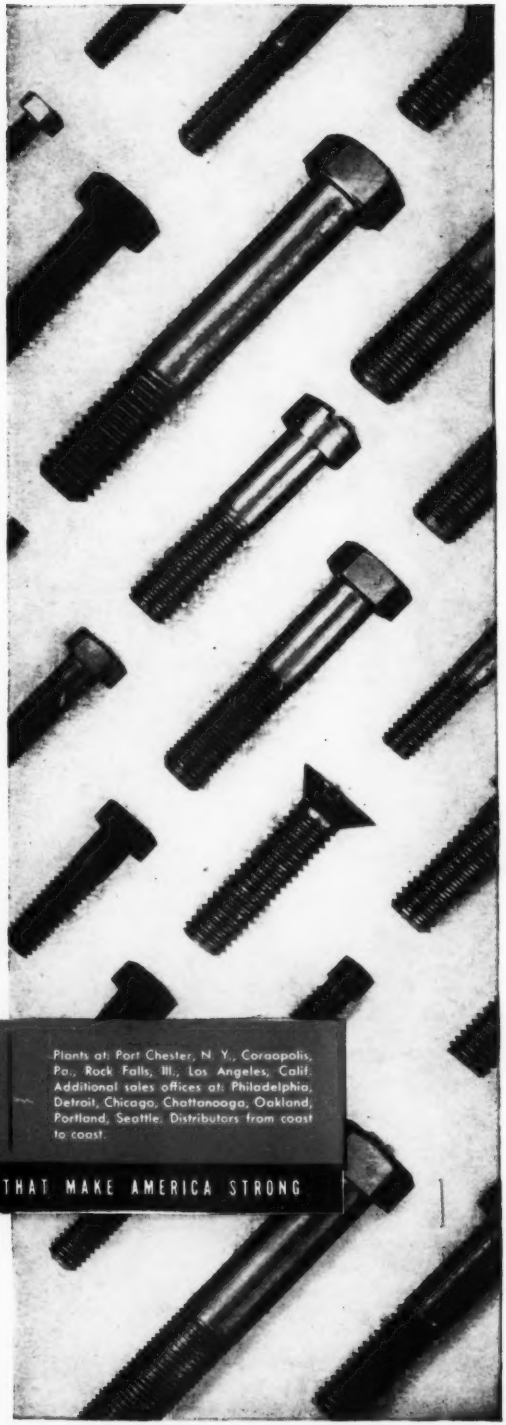
These illustrations show only a few of the many Baldwin accessories that will implement existing machines for broader fields of use, and make them an even more valuable tool in scientific progress and industrial development. Some of these accessories can be used on any make of machine . . . others are limited to certain types. You will find complete information on each individual device in its special bulletins; the numbers are listed.

A new bulletin on grips and accessories—No. 261-A—is just off the press. It lists a number of the items illustrated, as well as others, and will be a helpful addition to your testing equipment file. We will be glad to send a copy on request.

The Baldwin Locomotive Works, Philadelphia 42, Pa., U.S.A. Offices: Boston, New York, Philadelphia, Houston, St. Louis, Chicago, Cleveland, Pittsburgh, San Francisco, Seattle, Washington. In Canada: Peacock Brothers, Ltd., Montreal, Quebec.

testing headquarters → BALDWIN

Fastener appearance that contributes to the sales appeal of the final product—helps you get *True Fastener Economy*. The exceptionally fine finish of RB&W Cap Screws and Square Head Cup Point Set Screws is the product of more than a century of continuous research and progressive development in fastener manufacturing . . . backed by the skill of four generations of RB&W men and women.



R B & W

THE COMPLETE QUALITY LINE

Plants at: Port Chester, N. Y., Coraopolis, Pa., Rock Falls, Ill., Los Angeles, Calif. Additional sales offices at: Philadelphia, Detroit, Chicago, Chattanooga, Oakland, Portland, Seattle. Distributors from coast to coast.

104 YEARS MAKING STRONG THE THINGS THAT MAKE AMERICA STRONG

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

CHECK TOLERANCES

FROM "TENTHS" TO "HUNDREDTHS"

BY SIMPLE TURN OF GRADUATION SELECTOR

Only Brown & Sharpe Electronic Measuring Equipment offers this advantage

By the simple turn of a graduation selector, you get accurate readings in the desired increment from .0001" to .00001", on Brown & Sharpe Electronic Measuring Equipment. No further manipulations! The amplifier unit below shows the range. In addition, intermediate settings can be made easily to match prescribed tolerance limits.

The *true linear response* of the amplifier permits accurate calibration of scale graduations. Its versatility particularly simplifies special applications in production inspection and sorting devices.

Other exclusive advantages of Brown & Sharpe Electronic Measuring Equipment include a simple, self-checking device on the External Comparator . . . no gage blocks needed . . . and a constant zero setting regardless of changes in increments of measurement. Investigate all advantages of this quality-control aid. Write for Bulletin. Brown & Sharpe Mfg. Co., Providence 1, R. I., U. S. A.

We urge buying through the Distributor

External Comparator No. 951

Range, 0-4". Simplified setting. One master only. Reversible anvil. Self-checking. Shock-protected. Diamond gaging point.

Internal Comparator Attachment No. 952

Range ½" to 2". Frictionless. No pivots to wear. One master only. One measuring point and measuring bar serve any plug.

Gage Head Cartridge No. 953

For mounting in jig or fixture. Its range of measurement is .002" with a small added over-travel which measuring point makes. Frictionless. Dust and moisture proof.

Signal Light Attachment No. 958

Optional Equipment. Speeds operations. Provides visual indication of work size. Easily and securely attached.

BROWN & SHARPE

NASH DASH PANELS ARE COATED WITH LOGOQUANT*

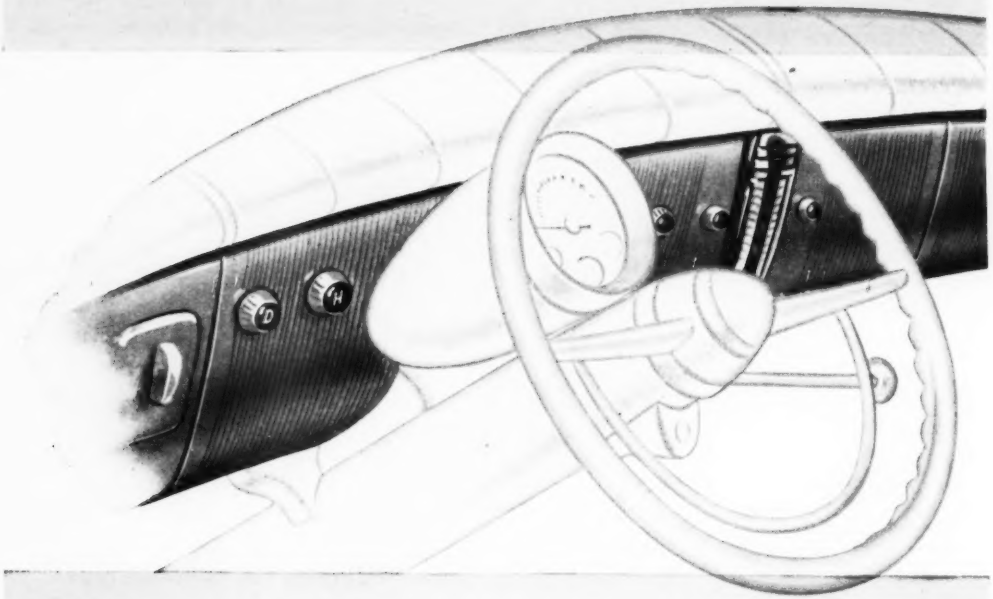
General American is the only major plastics manufacturer currently equipped to use—and actually using—lustrous, protective Logoquant. This new type of coating greatly increases the resistance of plastics to chemicals and abrasives. It gives a bright, glowing finish of unusually high clarity.

NO COLOR MATCHING PROBLEM!
NO NEED FOR CODING BATCHES!

The three parts of the Nash panel are always perfectly matched for color, whether they are molded from the same batch of material or not. The facilities of General American's large, completely equipped new paint shop are available to all customers who require true, perfectly-matched, long-lasting colors.

handsome!

Nash



ASK HOW GENERAL AMERICAN CAN SAVE YOU TIME AND MONEY ON PLASTIC PARTS

Ash trays
Cigar lighter caps
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Instrument panels
Light switches
Radio panels and control knobs
Steering wheels
Window and door control knobs
Windshield wiper control knobs
AND MANY OTHER PRACTICAL PLASTIC PIECES

Plastics Division

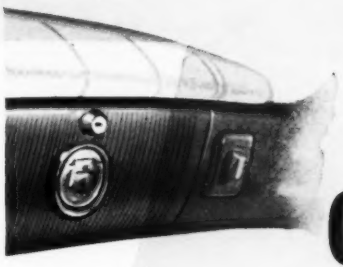
PLASTICS DIVISION GENERAL AMERICAN TRADE MARK

GENERAL AMERICAN

rugged!

DASH PANEL

molded and painted by



General American

NEW—LARGE, COLOR-MATCHED POLYSTYRENE PANELS MADE POSSIBLE FOR INDUSTRY

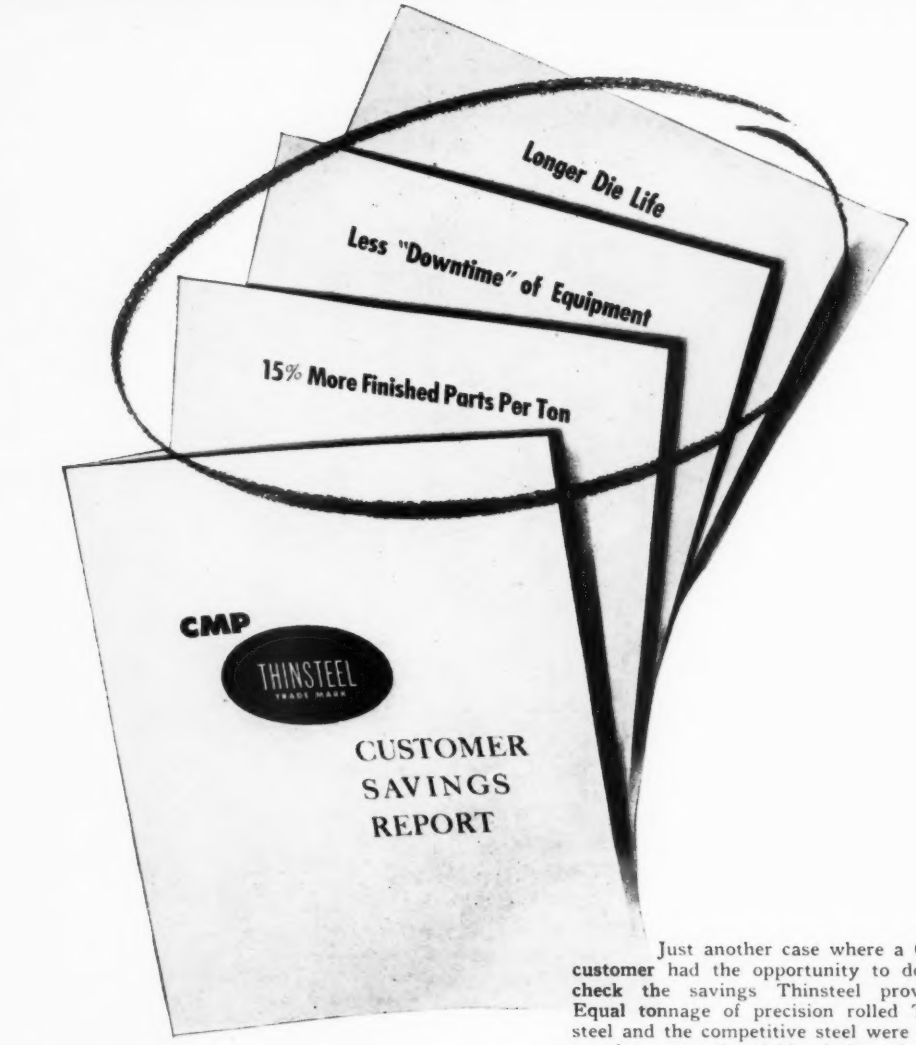
Nobody believed it could be done! "It's impossible," they said, "to get dimensional stability when molding a radio dial scale and other compound curvatures into single panels of polystyrene." But take a look at the ultra-violet resistant polystyrene dash panel of the handsome, new Nash. See its high-gloss three-dimensional effect beauty. It's the first successful large size polystyrene part for the automotive industry . . . molded by General American and coated with Logoquant.*

The same kind of creative thinking and research which produced this job is available to all General American customers. At General American you can use equipment such as 2 to 48 oz. injection presses and 100 to 2000 ton compression presses (with 71" x 74" platen areas). Complete finishing and assembling facilities are also at your disposal.

TECHNICAL DATA: Three molded parts—glove-box door, instrument panel and radio panel—are made on 16 oz. and 22 oz. injection presses. Eight molds produce the parts for both left-hand and right-hand drive cars. Tools are designed and built by General American.

TRANSPORTATION CORPORATION

135 South LaSalle Street, Chicago 90, Illinois • New York, 10 E. 49th St. • Los Angeles, Richfield Bldg.



Just another case where a CMP **customer** had the opportunity to double **check** the savings Thinsteel provides. **Equal tonnage** of precision rolled Thinsteel and the competitive steel were compared on normal and identical production runs . . . the cost saving facts are headlined above. It's typical of Thinsteel customers' reports in our file. So when you are planning product improvement and want to keep costs competitively right it would be worth checking Thinsteel availabilities. Your inquiry will bring interested attention from this pioneer in precision cold rolling.

NEW YORK • CHICAGO • DETROIT • ST. LOUIS • INDIANAPOLIS • LOS ANGELES

NICHROME* V

"heat-powers" the largest continuous strip annealing lines in the world

Here are the two largest continuous strip annealing lines in the world—provided in ultra-modern, electrically-heated vertical strip furnaces built by the Drever Company, of Philadelphia, Pa., for Carnegie-Illinois Steel Corporation's Vandergrift Plant.

Each furnace is rated 1820-KW, and its multi-pass annealing line is equipped with 13 heating, holding and slow cooling zones for atmosphere annealing at temperatures up to 2000°F. Strip speed can be varied from 30 to 300 feet per minute. Thus every degree of heat treatment, through variations of temperature and time, is obtainable.

When annealed, strip is delivered to coiling equipment absolutely flat—from edge to edge—so that coils are built up accurately, dense and "square". Up to 10 tons of 42" silicon steel strip per hour can be handled thus by each furnace.

The importance of avoiding delays necessitated by repair or replacement, in an installation of this size and scope, cannot be exaggerated. Furnace "downtime" quickly drives up production costs, wipes out profits. For the all-important, punishment-absorbing heating elements, therefore, the Drever Company has specified Nichrome V, recognized as the world's most dependable resistance material for heating devices.

The exceptional uniformity of Nichrome V assures precision heat control thruout the furnace; and the outstanding ability of this *high heat- and corrosion-resistant* alloy to retain its physical and electrical properties at elevated temperatures, assures trouble-free operation, long life . . . *reduced heat hour costs.*

Nichrome is not only available as electrical resistor material for heating elements, but also in cast forms comprising a complete line of heat-treating equipment, from furnace parts to carburizing retorts and muffles. Send us your specifications. We'll gladly make recommendations.

The complete line of each of these Drever furnaces consists of two uncoilers for handling cold reduced coils; multiple seam welder; continuous strip cleaner; looping pit to secure accurate guiding and tensioning; 13 zone controlled-atmosphere annealing furnace, with cooling tower, drive bridle for forwarding strip; guided and controlled tensioning for recoiling; 2 recoilers.

Nichrome V Strip, 1½" wide x ⅛" thick, is looped as indicated to form heating elements.

*Nichrome is manufactured only by

Driver-Harris Company

HARRISON, NEW JERSEY

BRANCHES: Chicago, Detroit, Cleveland, Los Angeles, San Francisco, Seattle

50TH YEAR
SPECIAL PURPOSE ALLOYS SINCE 1890
TRADE MARK REG. U.S. PAT. OFF.
D H
1899 - 1949

*T.M. Reg.U.S.Pat.Off.

Rubber by
CONTINENTAL

lends an "extra hand" at milking time

Here's a rubber part that's a real time saver. It's a "rubber hand" which, by means of intermittent vacuum, does the work of a human hand in machine milking.

Superior flexing properties are a prime requirement. A mirror smooth interior finish must be maintained . . . pits or rough spots catch milk particles, make cleaning and sterilizing more difficult. The rubber must be highly resistant to butter fat, acids, and sterilizing solutions. And finally, it must not impart foreign taste to the milk.

Continental has met all these strict requirements. The successful production of such intricate parts is typical of the skilled "technical service in rubber" offered by Continental.

When *you* need rubber parts, why not call on Continental?

• This little Booklet will help you.

3 MINUTES reading time will give you a new appreciation of the way in which rubber specialists can help you. Just ask your secretary to write for this factual booklet today.

CONTINENTAL
RUBBER WORKS

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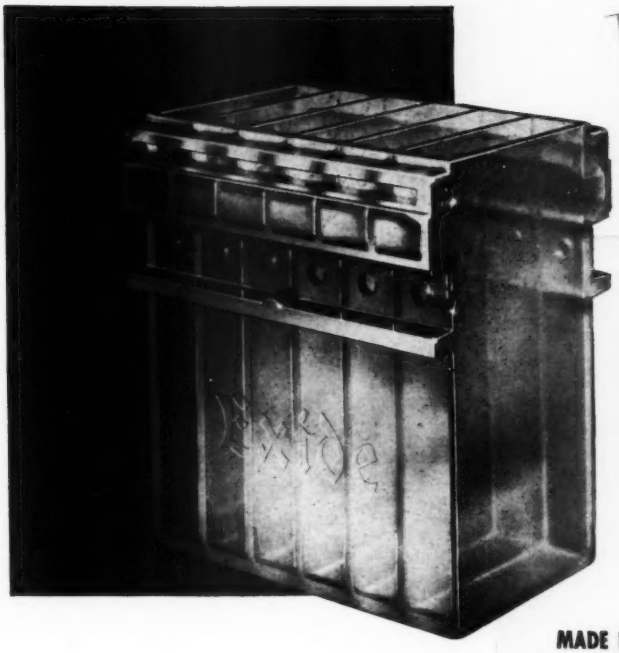
ONE ISSUE... 10,000 MILES

If you've ever wondered how PRODUCT ENGINEERING's editors manage to bring you all the information they do, one answer lies in the time these editors spend in the field, talking to design engineers throughout industry.

In June, for example, PRODUCT ENGINEERING will explore the subject of "Designing for Lower Costs." And no subject as important as this can be *thoroughly* explored from the narrow confines of an editorial office.

So our editors are already taking to the road . . . to talk and compare notes and ideas with the men who are sparking industry's drive for lower costs. They will have travelled over 10,000 miles before they're through. And when you sit down in June with this special issue of PRODUCT ENGINEERING, it will be, in a sense, just like taking off, yourself, on a nation-wide trip that would take you into most of the engineering departments of the companies which lead America's continual quest for better products for more people at prices *all* people can afford to pay.

PRODUCT ENGINEERING



Battery Case

Largest Single-Shot of Polystyrene ever molded!

MADE BY STOKES MOLDED PRODUCTS, INC.
Subsidiary of Electric Storage Battery Company

To our knowledge, this battery case is the largest single-shot of polystyrene ever molded. It contains 9 pounds 2 ounces of Koppers Heat-Resistant Polystyrene 8. The dimensions are 11 x 8½ x 12 inches with an average wall thickness for the case of ¼ inch.

Hundreds of other battery cases have been molded of Koppers Polystyrene because of its excellent combination of properties. It resists all concentrations of battery acids, has extremely low water absorption and is considerably lighter than materials previously used in battery cases.

The electrical properties of Polystyrene 8 are excellent and its heat resistance under A.S.T.M. test D 648-45T is 204°F.

In addition to all its superior qualities, the cost of Polystyrene 8 is low. That's why it is used for so many plastics products from kitchenware to the most modern refrigerators.

Koppers Polystyrene is made in three types—

- **Koppers Polystyrene 8,** the heat-resistant polystyrene.
- **Koppers Polystyrene 7,** the general purpose type.
- **Koppers Polystyrene 3,** the lubricated type for fast, easy moldability.

Koppers Technical Staff of research chemists and engineers is ready at all times to help you with your problems in plastics. Feel free to call on them. There's no obligation.

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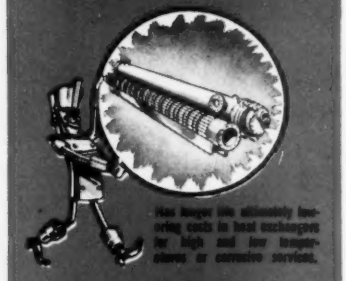
*POLYSTYRENE *ETHYL CELLULOSE *CELLULOSE ACETATE



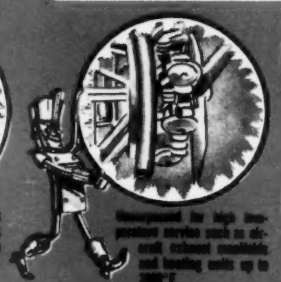
SPECIFY "Standard" STAINLESS for product improvement

Build in the quality your product needs to meet the challenge of competitive markets with "Standard" Welded Stainless Tubing. In many applications the ultimate cost of Stainless is less than tubing made from other materials. And you get smarter, more attractive styling—rugged durability—corrosion and heat resistance—in a tubing that can take it. "Standard" Stainless is easy to fabricate, resulting in more economical manufacturing techniques for you. Let Standard's 25 years of tubing experience assist you in developing methods for product improvement requiring the use of high quality Welded Stainless Steel Tubing.

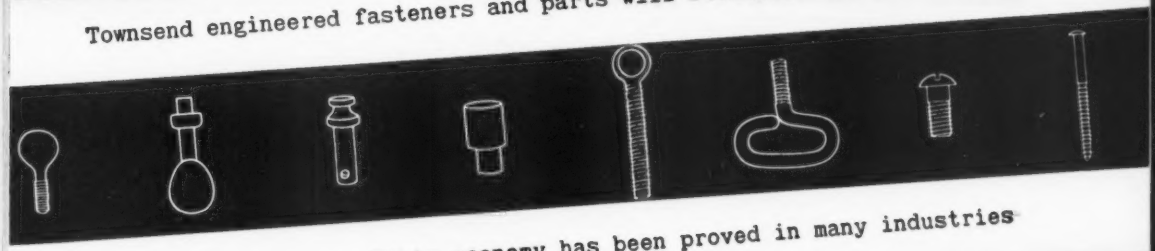
SIZE AND THICKNESS CHART
for STAINLESS STEEL TUBING

TUBE DIAMETER	MAXIMUM WALL		MINIMUM WALL	
*O.D. SIZE	DECIMAL	B. W. GAUGE	DECIMAL	B. W. GAUGE
3/8"	.035"	20	.025"	23
1/2"	.035"	20	.025"	23
5/8"	.049"	18	.028"	22
3/4"	.049"	18	.028"	22
7/8"	.065"	16	.028"	22
1"	.083"	14	.028"	22
1-1/8"	.083"	14	.028"	22
1-1/4"	.083"	14	.028"	22
1-3/8"	.083"	14	.028"	22
1-1/2"	.095"	13	.035"	20
1-5/8"	.095"	13	.035"	20
1-3/4"	.095"	13	.035"	20
1-7/8"	.095"	13	.035"	20
2"	.095"	13	.035"	20
2-1/4"	.095"	13	.035"	20
2-1/2"	.095"	13	.035"	20
2-3/4"	.095"	13	.035"	20
3"	.095"	13	.035"	20

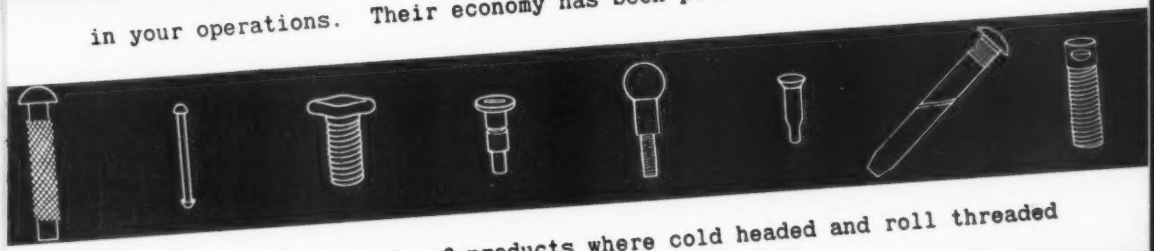
*Intermediate sizes within the range indicated can also be manufactured. Please consult us for sizes not listed.



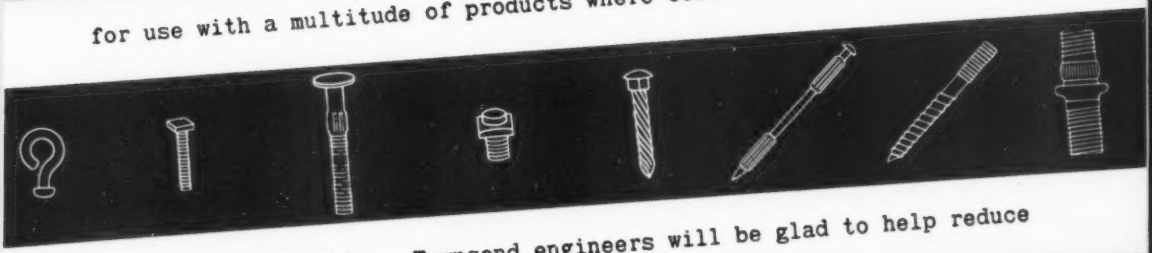
Townsend engineered fasteners and parts will save you time and money



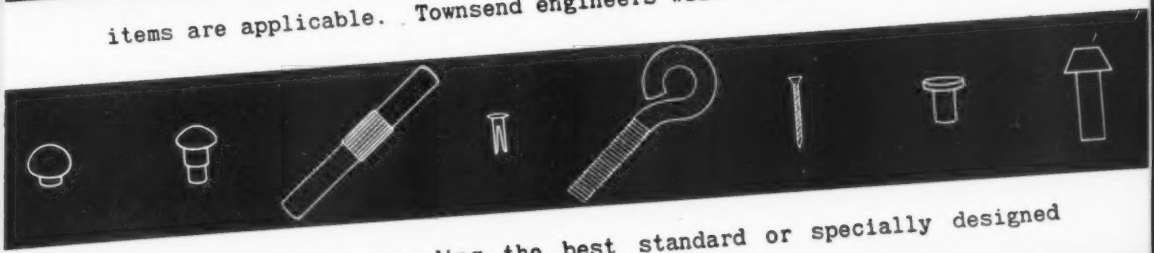
in your operations. Their economy has been proved in many industries



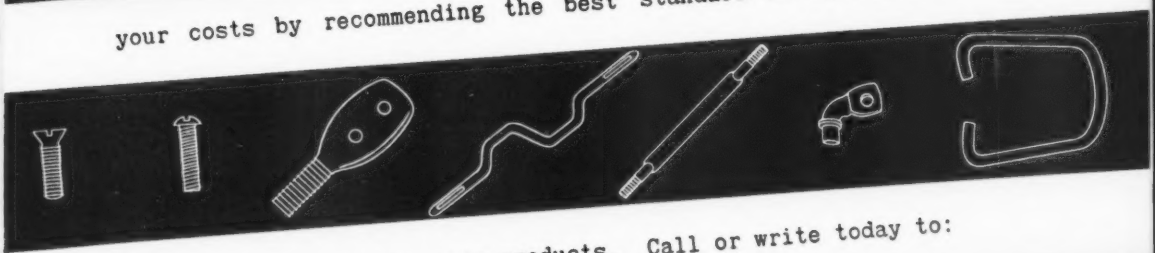
for use with a multitude of products where cold headed and roll threaded



items are applicable. Townsend engineers will be glad to help reduce



your costs by recommending the best standard or specially designed



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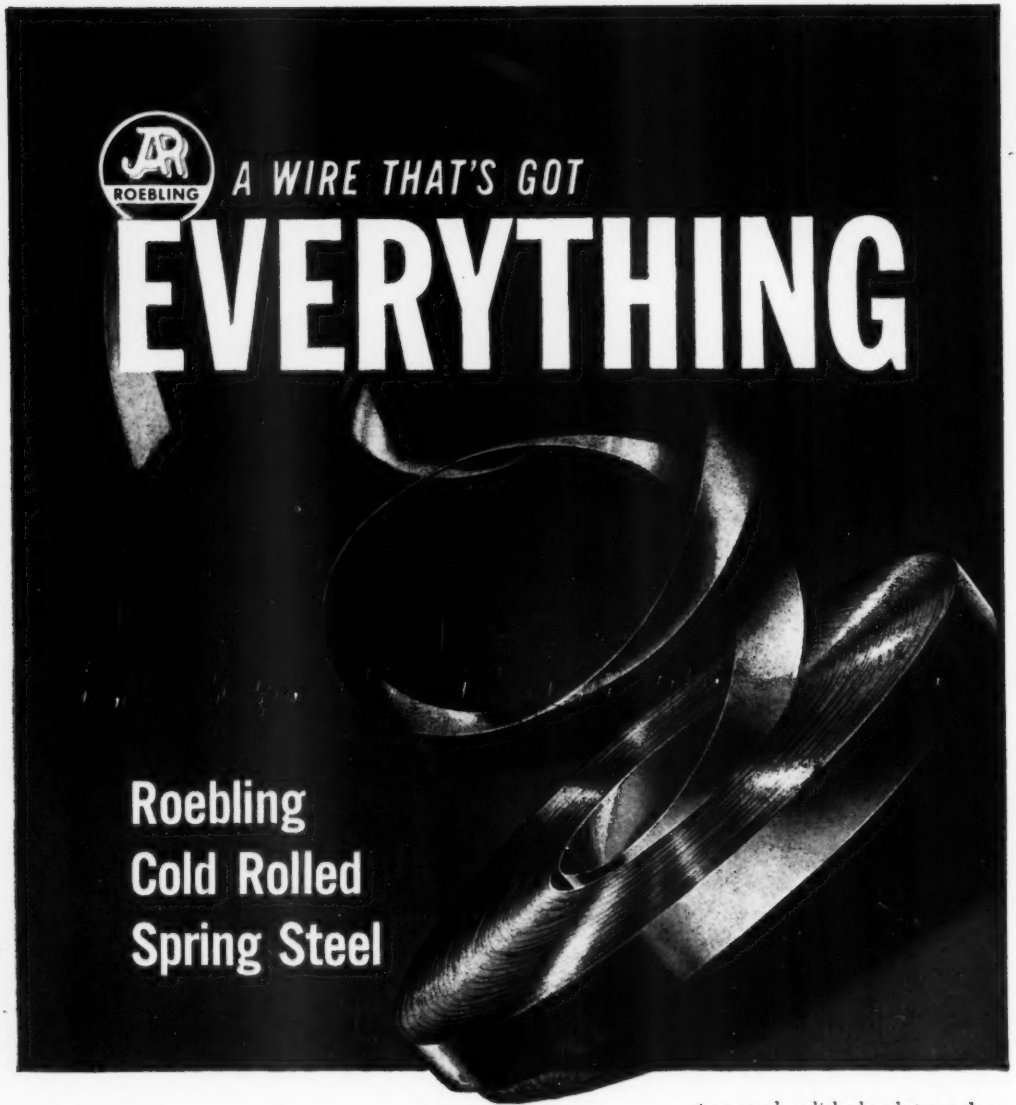

QUALITY THAT BRINGS ECONOMY

YOU KNOW what happens when you use wire uniform in gauge, grain, analysis, temper and finish. You save time and money... production goes up . . . stoppages and rejects come down. And those are the reasons why more and more manufacturers are adopting Roebling Cold Rolled Spring Steel.

With carbon content above 0.40%, you can now get Roebling Cold Rolled annealed and hard rolled untempered in bright finish. In the higher carbon ranges it is available tempered, in scaleless tempered; tempered and polished; tempered, polished and strawed; or tempered, polished and blued.

Have your Roebling representative help you select the *right* cold rolled spring steel, or round or shaped wire, for outstanding performance and worthwhile economy on your production lines and in your products. John A. Roebling's Sons Company, Trenton 2, New Jersey.

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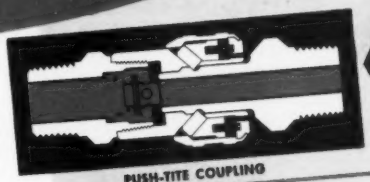
HANSEN COUPLINGS

HANSEN PUSH-TITE COUPLING

Shuts off one side of line

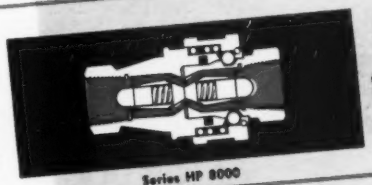
Gives quick connection and disconnection, with instant automatic flow or shut-off. To connect coupling, and open line to flow of fluid, merely push plug into socket. To disconnect, a slight pull on sleeve releases plug and shuts off supply end of line.



PUSH-TITE COUPLING

HANSEN HIGH PRESSURE TWO-WAY SHUT-OFF COUPLING

To connect, pull back sleeve and push plug into socket. Identical torpedo type valves permit free flow of gas or liquid through coupling. To disconnect, pull back sleeve . . . coupling immediately disconnects, valves automatically seal both ends of line. Can be mounted to disconnect automatically where fluid lines may be subject to sudden, damaging strain.



Series HP 8000

HANSEN STRAIGHT-THROUGH COUPLING

Provides quick connection and disconnection, but does not have shut-off feature. Size range for general use from ¼" to 2½". Two special types of straight-through steam couplings also available—one for low pressures, and one for high pressures.

Series ST Straight Through Coupling

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WRITE FOR CATALOG No. 47

giving descriptions and sizes of complete Hansen line of straight through and shut-off couplings for hydraulic and pneumatic connections.

QUICK CONNECTIVE FLUID LINE COUPLINGS...

THE HANSEN MANUFACTURING COMPANY

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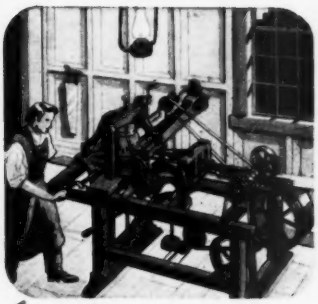
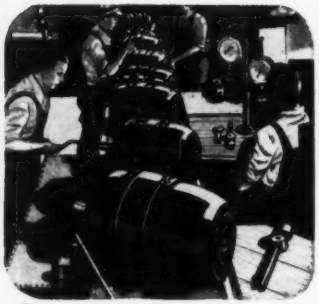


1 1865—Here's how machines looked before man applied electricity for industrial usage. Gear setups were crude. Making parts fit was a matter of luck and plenty of tinkering by operators.

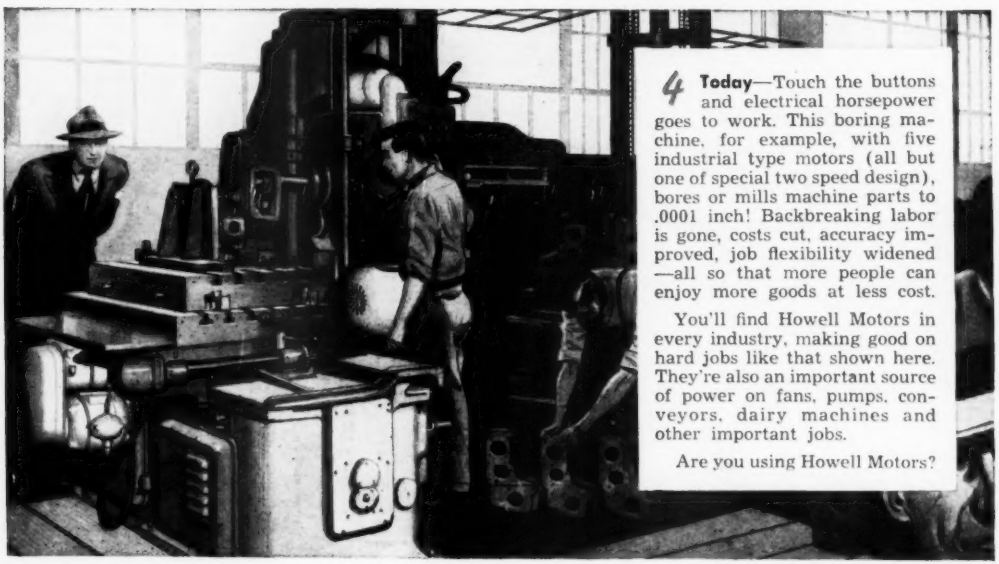
2 1907—Electrical horsepower gave production a big boost. But gear mechanisms were far too cumbersome. Repairs were frequent. Men were still struggling to make one motor do the work of many . . .



3 1915—Howell "Red Band" Electric Motors arrived. These rugged, industrial type motors were specially designed to withstand hard usage. Soon, Howell Motors appeared in this and other industries.

NOW, IT'S TOUCH AND GO!

(and parts are machined quicker and to closer tolerances)



4 Today—Touch the buttons and electrical horsepower goes to work. This boring machine, for example, with five industrial type motors (all but one of special two speed design), bores or mills machine parts to .0001 inch! Backbreaking labor is gone, costs cut, accuracy improved, job flexibility widened—all so that more people can enjoy more goods at less cost.

You'll find Howell Motors in every industry, making good on hard jobs like that shown here. They're also an important source of power on fans, pumps, conveyors, dairy machines and other important jobs.

Are you using Howell Motors?

Free enterprise encourages mass production, supplies more jobs—provides more goods for more people at less cost.

Here's another precision-built Howell Motor . . . industrial type with copper or bronze bar rotors . . . specially insulated . . . statically and dynamically balanced.

Howell Protected Type Motor

HOWELL MOTORS

HOWELL ELECTRIC MOTORS CO., HOWELL, MICH.

Manufacturers of Quality Industrial Type Motors Since 1915

Seeing is Believing

IN METALLURGY

HERE ARE TWO PICTURES OF THE SAME THING . . . above a section of Tobin Bronze* Rod. At right a micrograph at 75 diameters of a polished and etched specimen cut from the rod. *Reg. U. S. Pat. Off.

YOU'LL FIND few better examples of precise workmanship and careful selection of materials than this latest model of the Bausch & Lomb Research Metallograph. With this precision instrument a skilled laboratory technician may examine and photograph metal structure at high magnification. To build it Bausch & Lomb use 61 parts made from seven Anaconda Copper Alloys. Eight parts are formed from tube, 16 from strip and 37 from rod.

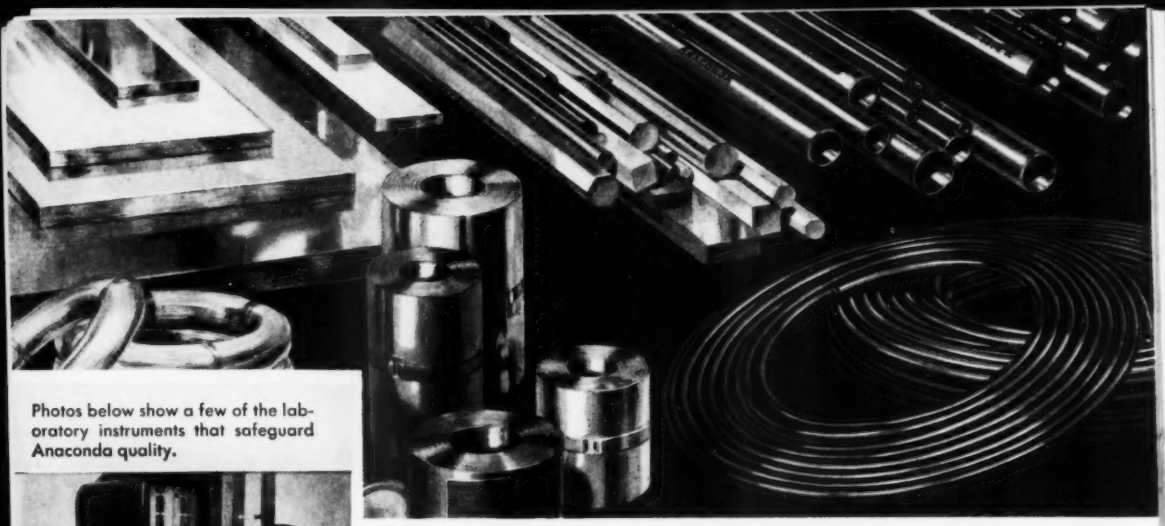
Of what advantage are these alloys? First, they provide accurate, smooth surfaces on delicate working parts. They lead to production economies through higher speeds and longer tool life. Availability of just the right alloy for a specific purpose is typified by the use of Anaconda Alloy 243 (with low lead content) for parts requiring knurling. Also there's ease and economy in applying finishes such as light-absorbing matte-black, or gleaming chromium plate.

Manufacturers in general may be sure that the wide range of Anaconda Metals will blanket their needs. You can depend on the right composition, temper and grain size for a given part, whether it is to be machined, forged, rolled, spun, stamped, pressed, coined, upset or drawn. Next Page Please . . .

ANACONDA

THE AMERICAN BRASS COMPANY

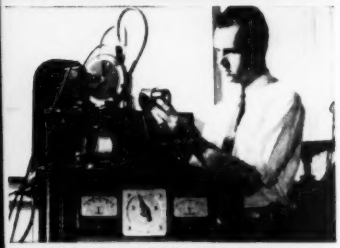
General Offices: Waterbury 88, Connecticut



Photos below show a few of the laboratory instruments that safeguard Anaconda quality.

A.R.L. Densitometer-Comparator

Evelyn Photo-Electric Colorimeter



Picker X-ray Diffraction Unit

Grain Size Comparator

Quality Control

AT THE MILLS

EXTENSIVE, routine use of the new Bausch & Lomb Research Metallograph (described on preceding page), and many other tools of modern metallurgical research, assures the utmost uniformity and dependability in Anaconda Copper and Copper Alloys.

At the turn of the century, The American Brass Company, already the largest fabricator of copper and copper alloys, led the way in the search for greater metallurgical knowledge, and instituted laboratory control of alloy compositions to replace the father-to-son methods of mixture determination that had prevailed from the beginnings of the industry.

From that day on, the activity and responsibilities of the Technical Department have grown with the rapid advance of technical knowledge and instrumentation. Today more than half a million tests are made annually in the course of maintaining laboratory control over all mill operations and practices.

Such planned research and routine quality control is your assurance of Anaconda Metals that will fully meet your manufacturing requirements.

THE AMERICAN BRASS COMPANY

General Offices: Waterbury 88, Connecticut

Subsidiary of Anaconda Copper Mining Company

In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

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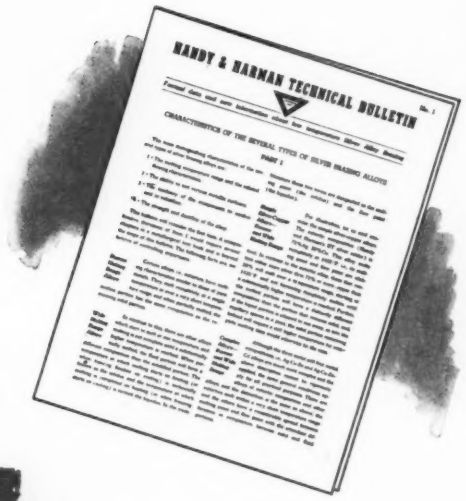
Investigation into every phase of low-temperature silver alloy brazing is being carried on continually in our Research Laboratories.

Believing that many engineers are interested in the valuable factual data and new findings being uncovered, we are making the data available in the form of Bulletins, two of which, covering characteristics of various types of silver brazing alloys, have already been published. Included among the subjects of future bulletins are—

- Strength of Joints—Tensile, Shear, Impact and Fatigue
- Joint Design from Standpoint of Stress Distribution
- Expansion and Contraction of Parts in Brazing
- Diffusion and Alloying with Joint Components
- Fluxes—Functions and Special Compositions
- Brazing Cast Iron

If you would like to receive free copies of these strictly *Technical Bulletins* as they are published, fill in and mail the COUPON and we'll send you those already issued and put your name on the mailing list for future copies.



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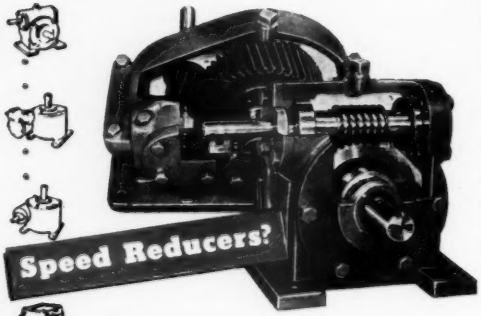

Worm, double worm, compound worm and spur, helical, mitre gear — Grant makes them all . . . reductions up to 3660-1 . . . most types available from stock. Write for catalog describing each type in detail.

Special requirements? . . . unusual and difficult jobs are a Grant specialty . . . for an estimate write outlining your problem.

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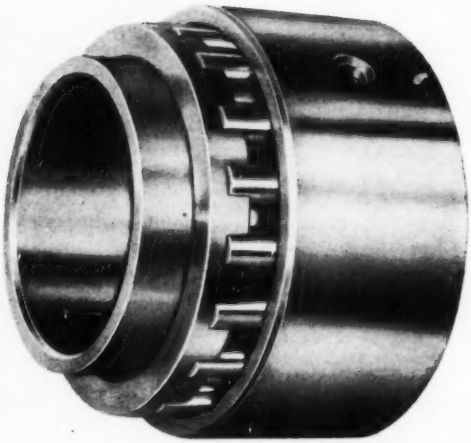
"Extra" Heavy-Duty
Roller Bearings

for the toughest anti-Friction jobs



Here is a "super" bearing designed especially for *super heavy-duty* service. Its simple construction, absolute precision and tremendous strength assure smooth, dependable performance in the heaviest machinery under the most difficult operating conditions. Complete technical data furnished without obligation. Write.

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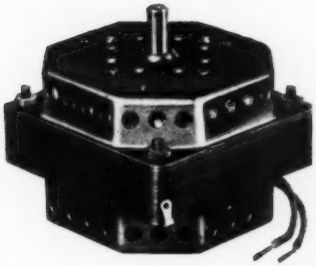
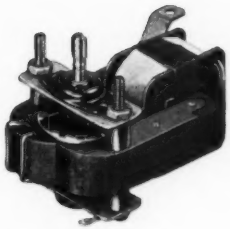


MODEL D-6 (1/100 H.P.)

4-pole, shaded pole induction motor. Free Speed—1735 R.P.M. Locked Rotor Torque—2¾ in. oz.—H.P. (at 1400 R.P.M.)—1/100; Dimensions: 3⅜" square x 2⅜" over bearing housings. Features include dual cooling fans . . . dynamically balanced rotor . . . self-aligning, oiless sleeve bearings.

small motors... for Important Jobs!



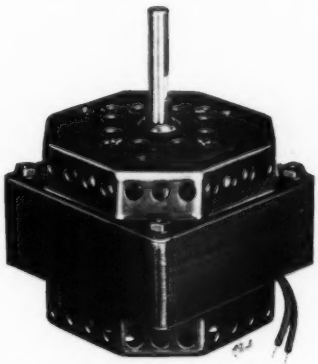
MODEL C-5 (1/300 H.P.)

2-pole, shaded pole induction motor. Free Speed—3370 R.P.M. Locked Rotor Torque—0.9 in. oz.—H.P.(at 2600 R.P.M.)—1/300; Dimensions: 2" wide x 3½" long x $2\frac{7}{32}$" high. Features include accurately aligned motor shaft . . . oiless bearings . . . dynamically balanced rotor.

Whatever your performance requirements, check the features and specifications of these tried and proved GI Smooth Power small motors—1/70 H.P. and under.

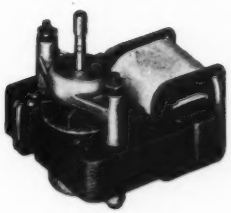
Long recognized for their superiority in the radio-phonograph industry, each of these motors is extremely compact . . . light in weight . . . designed and built for trouble-free long life. Their cost, however, is surprisingly low. Design modifications are available where quantities warrant production line changes.

Blueprints or quantity price quotations sent immediately upon request. Write, wire or phone *today*.



MODEL D-10 (1/70 H.P.)

4-pole, shaded pole induction motor. Free Speed—1740 R.P.M. Locked Rotor Torque—4¾ in. oz.—H.P. (at 1500 R.P.M.)—1/70; Dimensions: 3⅜" square x 3⅛" over bearing housings. Features include scientifically designed air intake . . . dual cooling fans . . . dymanically balanced rotor . . . self-aligning oiless sleeve bearings.



MODEL A-5 (1/250 H.P.)

2-pole, shaded pole induction motor. Free Speed—3470 R.P.M. Locked Rotor Torque—1.2 in. oz.—H.P. (at 2800 R. P. M.)—1/250; Dimensions: 2½" wide x $3\frac{3}{32}$" long x 2¼" high. Features include novel bearing construction which insures rigid and permanent alignment of motor shaft . . . oiless bearings . . . dynamically balanced rotor.

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An insulating material, light in weight, resistant to wear, with good dielectric strength, ready machinability. National Vulcanized Fibre with all these qualities, plus—*was the perfect answer.*

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NATIONAL VULCANIZED FIBRE — A tough, horn-like material with high dielectric and mechanical strength. Excellent machinability and forming qualities, great resistance to wear and abrasion, long life, light weight. Sheets, Rods, Tubes, Special Shapes.

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PEERLESS INSULATION — The *first* fish paper developed for electrical insulation. Strong, smooth, flexible, with excellent forming qualities. High dielectric strength. Sheets, Rolls, Coils.

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Sold ONLY through plumbing and heating wholesalers. See them. . . . Ask for . . . .

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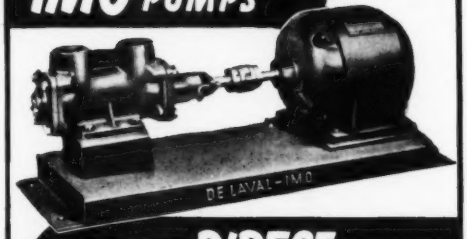

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The IMO pump can be connected directly to turbines, motors or other machinery without the use of reduction gears.

Operated at high speed, it is exceptionally small and compact in proportion to its capacity.

IMO pumps can be furnished for almost any capacity and pressure required for pumping oil, hydraulic control fluids and other liquids over a wide viscosity range.

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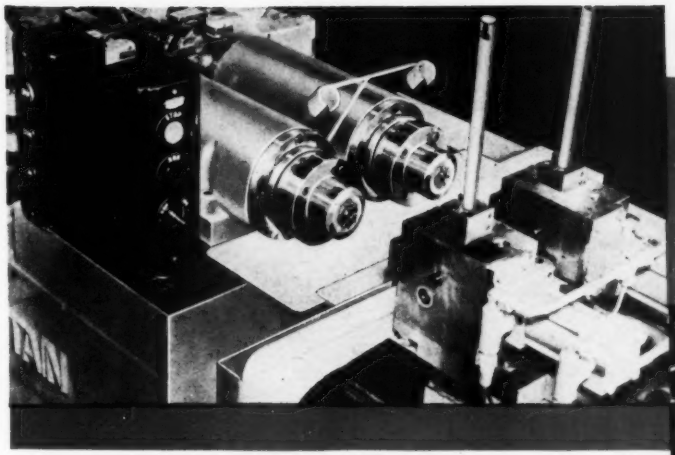
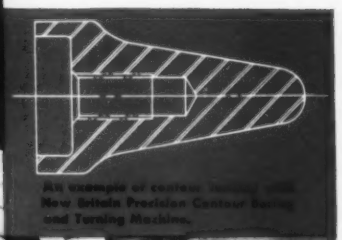
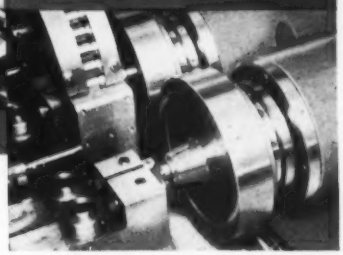
HITTING .000025 ON THE NOSE 7500 TIMES A MINUTE!







New Britain calls on ball bearings to "hold it"

This new cam actuated Precision Contour Turning and Boring Machine is slashing costs of second operation work by holding tolerances to incredible limits and stepping up spindle speeds as high as 7500 r.p.m. A typical performance . . . .0001 limit on size from end to end on valve guides, .0002 limit on concentricity and .0006 limit from piece to piece. Production rates are jumped from 180 to 300 pieces on one job and to as high as 1800 pieces an hour on another. At such speeds and tolerances, spindles, and particularly spindle bearings, have a real holding job.

Spindle "truth" that's hard to believe

If there's any deviation of this spindle at top speeds, you'd have a hard time finding it. But New Britain's designers modestly claim only a quarter of a tenth at 7500 r.p.m., generously give much of the credit to Fafnir Super-Precision Ball Bearings. At the work end equal length spacers between bearings increase rigidity. The rear pair is "floating".

Name your tolerance and get it with Fafnir Super-Precision Ball Bearings

These super-precision ball bearings, pioneered by Fafnir, are the aristocrats of ball bearings. Instead of the customary precision grade, these bearings are made to the highest industry approved tolerances. Duplexing matched pairs and preloading to precise limits reduce deviation at high speeds, laterally and axially, to practically zero.

An ATTITUDE and an APTITUDE

What Fafnir offers you is more important than any particular ball bearing. It's an attitude and an aptitude . . . a way of looking at ball bearings from where you're sitting . . . an aptitude for doing just what you'd like done about it, gained from solving the bearing problems of not just one or two industries but of all industries. The Fafnir Bearing Company, New Britain, Conn.

FAFNIR

BALL BEARINGS

MOST COMPLETE LINE IN AMERICA

FOR PRECISION TUBING
WHATEVER THE . . .
SIZE Precision Tubing is available in sizes which cover a range of 0.500 inches to 0.010 inches outside diameter, wall thicknesses down to 0.0015 inches. Through continuous hydrogen atmosphere annealing furnaces and tungsten carbide tooling, dimensions you specify within this range are held to extremely close tolerances.
SHAPE Precision Tubing can be drawn to almost any shape desired and is often preformed to facilitate secondary operations. Round, rectangular, oval, or square—any dimensions you specify within Precision's standard ranges are produced to meet the most exacting dimensional requirements.
ALLOY Precision's continuous endeavor to use only the best metal for any particular application has imbued it with a sound working knowledge of an almost limitless variety of non-ferrous alloys. Controlled production cycles make possible the correct temper, a clean smooth finish, and the precise uniformity so essential to long life.
WHEN PRECISION COUNTS . . .
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MAGNESIUM DIE CASTINGS . . .

cut weight . . . cut fabricating costs . . .

They made . . .

pounds and parts disappear . . .

in this folding chair!

High fabricating costs literally vanished when this chair was designed in magnesium.

The 3 major parts illustrated plus 2 smaller die castings replaced 14 separate parts used in previous construction. The use of die castings made possible lighter and more efficient sections—metal is placed only where it is needed for strength, styling and assembly. Considerable machining and finishing were eliminated, too, because magnesium can be die cast to close tolerances.

Magnesium die castings provided economy and latitude in styling of chairs since several models can be made using the same basic parts. Attractive, durable finishes were used to further improve appearance.

The manufacturer of this chair solved two other important problems when he switched to magnesium: First, serviceability—magnesium will not warp, crack, or splinter; Second, *availability—magnesium is readily available and priced more favorably than ever before.*

Manufacturers of countless products find that it pays to use magnesium—it can pay for you, too.

Magnesium Pays

Write for this revealing free book "How Magnesium Pays". It's filled with actual case studies of how manufacturers of a wide range of products have found that magnesium pays.

Send me the study MP 49-35 "How Magnesium Pays."

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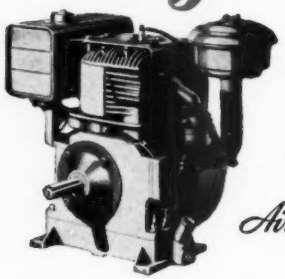
It will pay you to select Briggs & Stratton Engines



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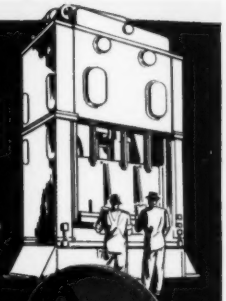

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Possibly you don't make or use heavy presses. But probably you *do* have jobs for Ampco Metal — tough jobs where you need the same superior performance that Ampco Metal gives in these press applications.

***Ampco 24 Extrusion Punch Outlasts the Best Steel 10 to 1**

The extrusion punch at the right extrudes a 5/8" hole to 3¼" diameter in a heavy gauge steel water heater head. The best steel punches produced 6600 pieces *maximum*. With the new Ampco Grade 24 punches runs of 65,000 pieces became *average*.

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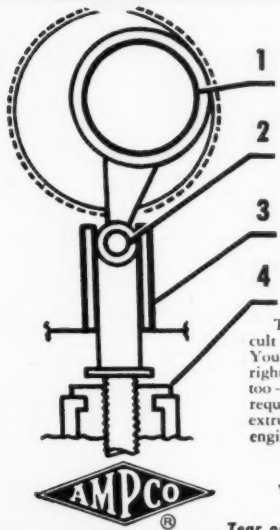

Bronze eccentric bushings — Ampco Grade 12 Bushings, centrifugally cast, provide a wear-resistant eccentric bearing lining that gives maximum heavy-duty service.

Bronze wrist-pin bushings — Ampco Grades 18, 18-23, or 20 centrifugally cast bushings withstand extremely heavy loads without mushrooming. (Ampco field engineers will be glad to recommend proper grade.)

Bronze-lined guides — Ampco 8 Sheet used as liners (gibs) give maximum life with minimum wear under varying conditions of load, speed, etc.

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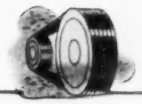

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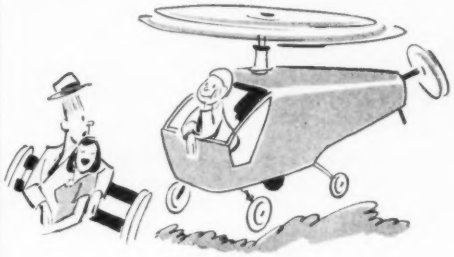
WHY V-BELTS? Because they ignore the deteriorating effects of dirt, dust, moisture and animal acids present in every barn. What's more, milking machines must be compact. V-Belt drives permit the use of shorter centers, smaller pulleys. Save weight and space.

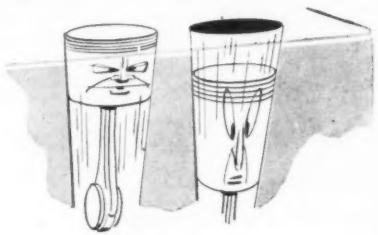


FLY A HELICOPTER. An aviation engineer has recently designed a helicopter that uses V-Belts to transmit the power from the engine to the rotors.

WHY V-BELTS? Because they are one of the most efficient methods of transmitting power known. They won't slip or stall. They are light, long wearing, easy to maintain. And they eliminate shafts, gearing and expensive machining.

SHAKE NUTS FROM A TREE. Raising nuts is big-time business. A leading pecan grower uses a steel cable and an eccentric drive (V-Belt driven) to gently shake the ripened nuts from the trees.

WHY V-BELTS? They absorb shock loads, withstand sudden power. They have a long service life, inexpensive. Operate anywhere with little or no maintenance.



KEEP TOLERANCES TO + or −.0001. When machine tool makers build machines that produce parts held to absolute tolerances, they depend on V-Belt drives to transmit the power.

WHY V-BELTS? Because V-Belts won't vibrate. They start and run smoothly. Absorb the shocks of sudden starts or overload.

WHAT HAVE YOU DONE WITH V-BELTS?

All of the above are drive applications design engineers have told us they have made using Dayton V-Belts. We share them with you in hopes they may help you in your work. We'd like, in turn, your experiences. If you have used V-Belts to solve an unusual problem and think it would help your fellow engineers, write and tell us. We'll be happy to publish it on this page, giving you full credit, of course.

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V-Belts have the happy faculty of making drives more efficient, or cheaper, or easier to maintain. Dayton engineers are skilled in how to use them. Dayton builds all kinds of V-Belts, for normal drives, high speeds, shortest possible centers, unusual conditions of heat, oil or static, and the like. They are available in all sizes. Write us your drive problem. We'll be happy to help you solve it. Address *The Dayton Rubber Company, Dayton 1, Ohio.*

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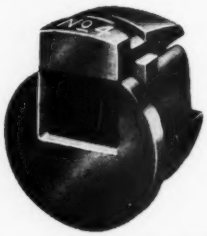

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Abbott B	1/16 — 5"	± .0002	.0002
Abbott C	1/16 — 5"	± .0005	.0005
Abbott Hardware	1/16 — 5/8"	± .001	.001
Abbott Industrial	1/8 — 5/8"	± .002	
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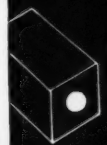
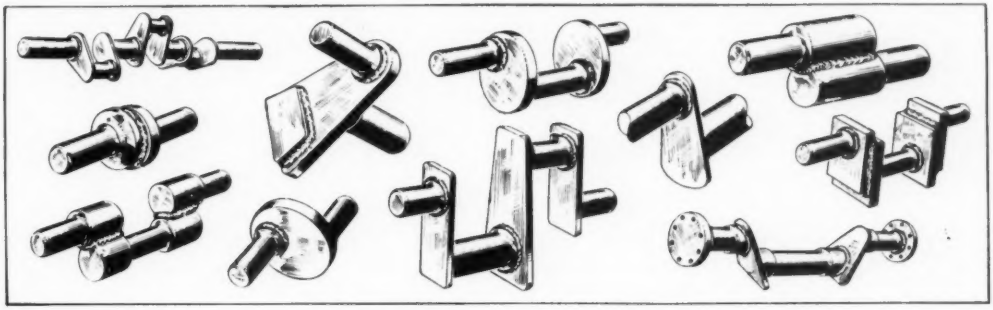


P.S.

The round hole in the square peg can help you with your burnishing problems, too. Ask for a sample kit.

How Stronger Cranks Are Built at Lower Cost with Arc Welding



Examples of cranks and crankshafts fabricated from steel at lower cost with arc welding.

Many machinery parts like these simple cranks are being fabricated from standard steel shapes, eliminating the need for forgings or castings. Shaft components for the cranks may be produced from bar stock, machined to form as simple lathe operations, and throw members flame-cut from steel plate. Component parts are tack welded first or are located in simple fixtures for welded assembly using electrodes suited to the type of steel used.

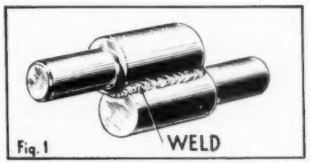


Fig. 1

Simplest of all cranks is shown in Fig. 1. Where accuracy of throw is unimportant, bars having a diameter equal to the throw can be fillet welded. If a longer crank throw must be maintained, the shafts can be fillet welded to a disc (Fig. 2) or two studs machined as shown in the lower sketch (Fig. 2) can be positioned back to back and the flanges fillet welded.

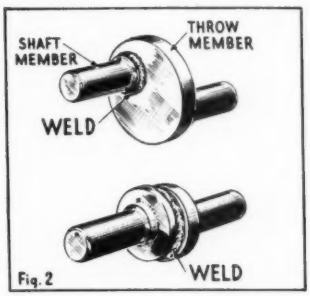


Fig. 2

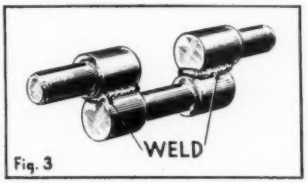


Fig. 3

Fig. 3 shows the elements of a single-throw crankshaft. On applications where the throw of the crank exceeds the diameter of the shaft members, discs cut from bar stock or flame-cut from steel plate are incorporated (Fig. 4).

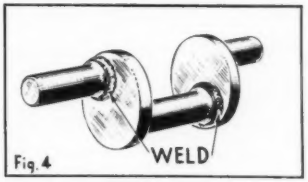


Fig. 4

To simplify the welded assembly of a crankshaft, the throw members can be built from rectangular stock and fillet welded as shown in Fig. 5, after which a trim cut may be taken on a lathe for appearance or balance.

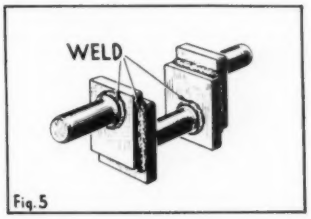


Fig. 5

Multiple throw crankshafts, as illustrated in Fig. 6, can be weld-fabricated to suit any requirements of size and throw. If necessary, different alloys can be incorporated in various component members to best suit the needs of the crankshaft. After welded assembly, the crankshaft can be

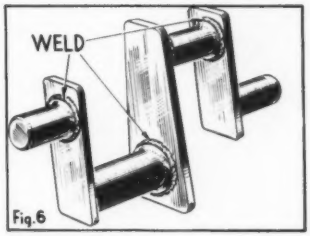


Fig. 6

machined all over in the conventional manner, accurately holding any size and throw specified.

Counterbalancing is easily accomplished by fillet welding weights to throw members as indicated in Fig. 7. Small deposits of weld metal can be added to any part of the crankshaft if unusually accurate balancing must be attained.

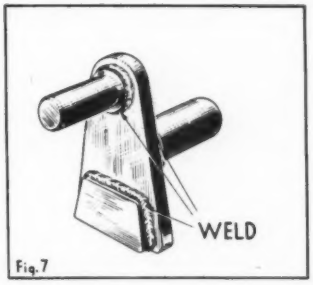


Fig. 7

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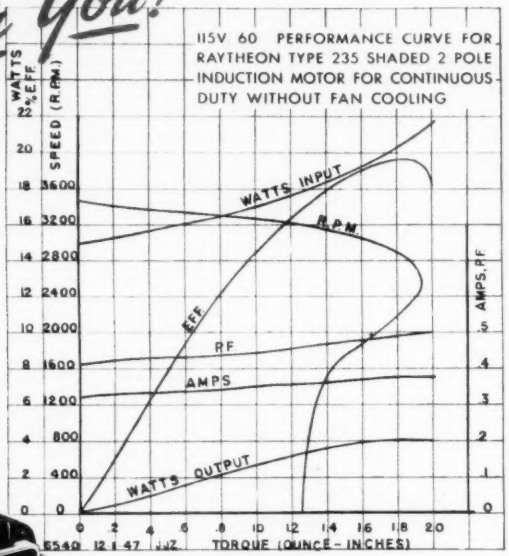
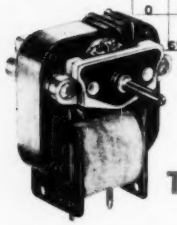


Type 230 De-Luxe Model with die-cast bearing brackets.



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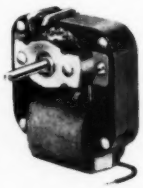

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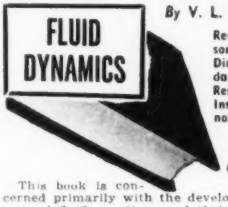

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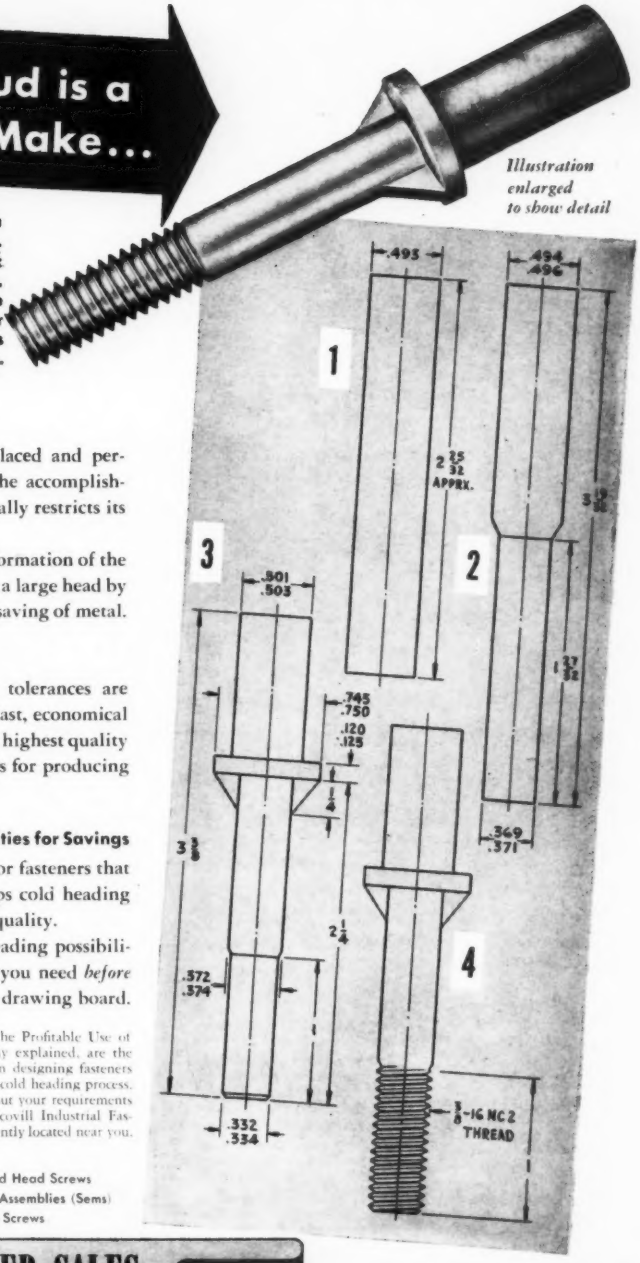

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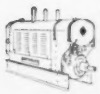
In boring holes for pier foundations, telephone poles or seismographic surveys, Williams Earth Drilling Machines frequently must bore through hard pan, slate or rock. That's when Allis-Chalmers high-torque power units show their ability to "hang on"—just like steam power—and handle hard drilling with ease.

Designed for tough tractor service, Allis-Chalmers engines provide heavy-duty power for any type of operation, continuous or intermittent. Their low first cost plus reliable, low-cost performance promotes customer satisfaction. So do the nation-wide service facilities. Let our power engineers help select the correct unit to fill your requirements.

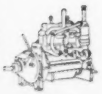


ENCLOSED

POWER UNITS — Five Sizes

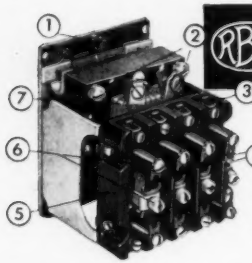
Model*	Cyl.	R.P.M.	Max. B. HP.
B-125	4	1500-1800	24.5—28.0
W-201	4	1400-1800	33.5—40.5
U-318	4	1200-1400	45.0—50.9
E-563	4	1050	74.0
L-844	6	1050	110.0

*figures represent cu. in. displacement



OPEN STYLE

ALLIS-CHALMERS
TRACTOR DIVISION — MILWAUKEE 1, U. S. A.



RBM INDUSTRIAL CONTACTORS

2 TO 8 POLE
600 VOLT A. C.
10—15 AMPERE SIZES
REVERSING—NON-REVERSING TYPES
INTERCHANGEABLE CONTACTS

1. Heavy steel base.
2. Coil readily replaced by removing 2 heavy screws holding E-shaped magnet frame.
3. Accessible solderless type terminals are conveniently located. All line terminals at top; load terminals at bottom.
4. Any pole can be changed from normally open to normally closed, or vice-versa, without additional parts.
5. Melamine stationary contact block and movable contact carrier.
6. Stationary and movable contacts can be readily replaced with use of screw driver only and without removing wiring.
7. Vacuum impregnated magnet coil designed for continuous 50/60 cycle service.

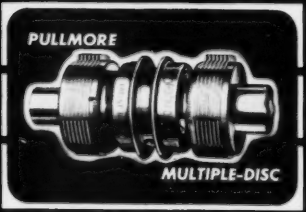
For descriptive bulletin No. 600 write Dept. E-4

R-B-M DIV., ESSEX WIRE CORP.
LOGANSPORT, INDIANA

RBM
MANUAL AND MAGNETIC ELECTRIC CONTROLS
—FOR AUTOMOTIVE INDUSTRIAL COMMUNICATION AND ELECTRONIC USE

Learning Your Clutch Needs | Analysing the Problem | Designing the Clutch | Planning Production | Tooling Up | Manufacturing | Checking and Testing | Supervising Installation | Servicing

Better CLUTCH Design Benefits PRODUCT Design



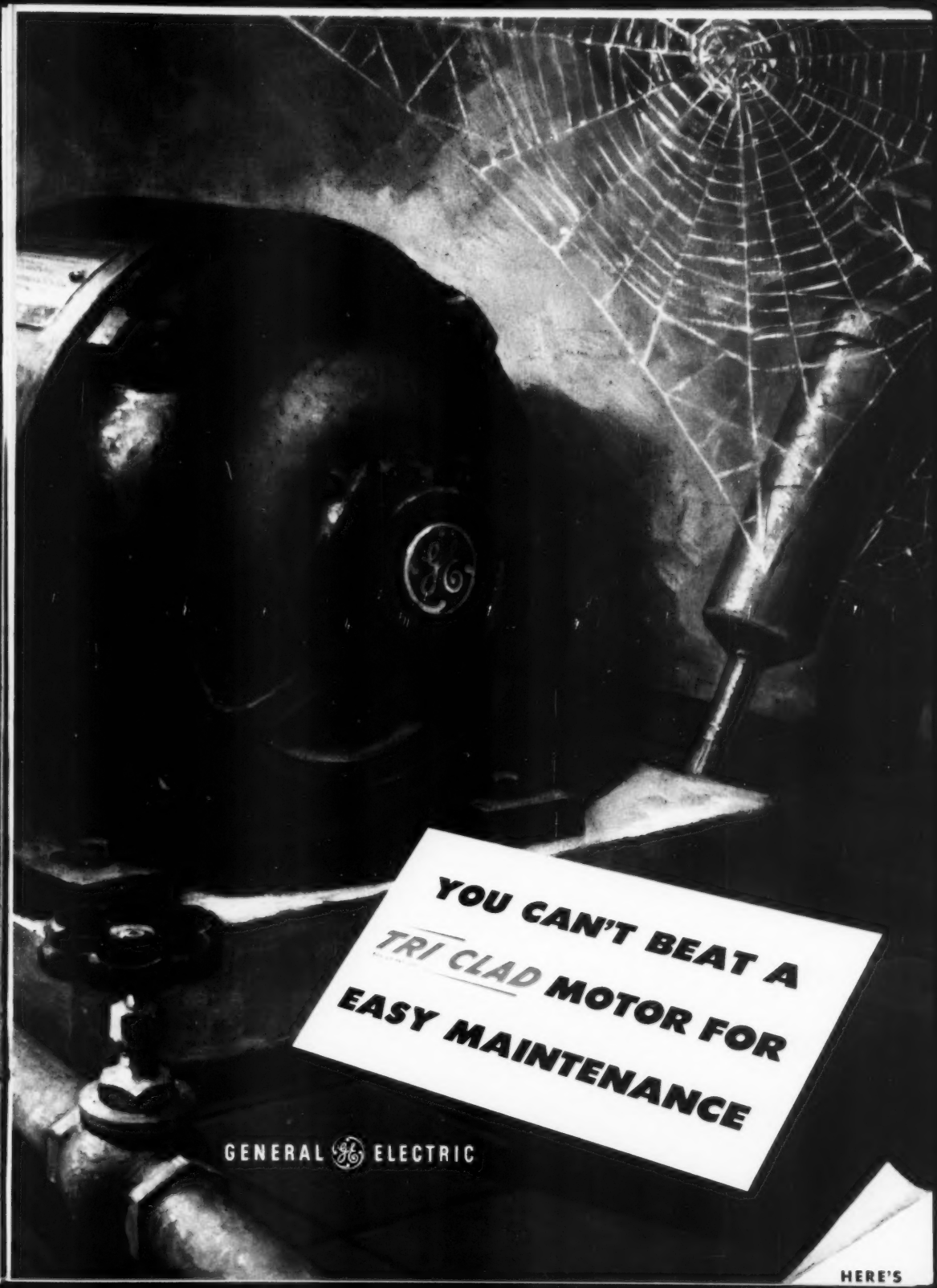
ROCKFORD CLUTCHES

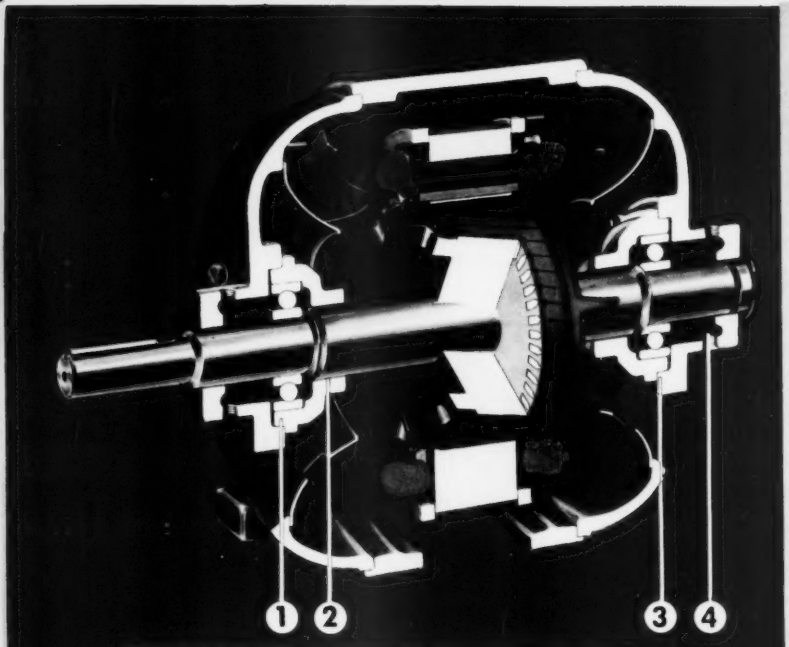
Fitting the clutch to the product — instead of the product to the clutch — requires that the clutch be designed, manufactured and applied to meet the products specific needs. Before you approve the design for your next model — double check to see if it includes all the improvements you can give it — with the *right* ROCKFORD CLUTCH application. You are invited to utilize the clutch "know-how" of our engineers to give your design the technical clutch advancements that will provide your product with important competitive advantages.

BW

ROCKFORD CLUTCH DIVISION
BORG-WARNER
209 Catherine Street, Rockford, Illinois

Automotive and Aircraft | Trucks and Buses | Tractors and Road Machines | Farm Machines and Implements | Oil Field Rigs and Pumps | Industrial | Mowers and Light Machines | Engines and Marine Units | Machine Tools Production Units


YOU CAN'T BEAT A
TRI CLAD MOTOR FOR
EASY MAINTENANCE
GENERAL ELECTRIC
HERE'S



Notice (1) how Tri-Clad bearings are surrounded by and rigidly supported in solid cast-iron housings. Compare the long, close-running fit between housing and shaft (2) with other motor bearings. Examine the tight rabbet fit between inner cap and end shield (3) which keeps dust and moisture out and lubricant in. See, too, the pressure-relief greasing system (4) that makes it easy to lubricate if you need to.

You can't beat a *TRI CLAD* motor for easy maintenance

A TRI-CLAD MOTOR will run safely without lubrication for years—for as long as any other general-purpose motor you can buy. The big thing is—it's *grease-gun easy* to lubricate a Tri-Clad if you need to.

You don't have to take a Tri-Clad motor down and disassemble the bearings to lubricate it. You don't have to follow special instructions. A standard gun and a good grease are all you need.

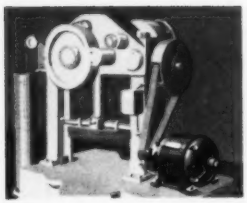
And remember, Tri-Clad gives you all the extra protection that only cast-iron structure can give . . . Extra protection against rust and corrosion . . . Extra protection against mechanical abuse and permanent distortion . . .

Extra protection that has been proved in more than 5 billion hours of rough-and-tumble industrial service.

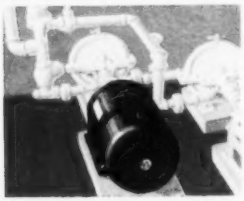
WANT TO SEE FOR YOURSELF? Tri-Clad motors in nearly all types and ratings are ready for **IMMEDIATE SHIPMENT.** Contact your nearest G-E Office or write *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

GENERAL ELECTRIC

There's a Tri-Clad motor for every industrial need!

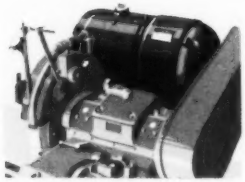


G-E open (dripproof) induction motors for constant-load, constant-speed applications. From 1 to 2000 hp.



G-E totally enclosed motors for operation where dust or corrosive fumes are a hazard. From 1 to 1000 hp.

G-E capacitor motors for use on fans, blowers, pumps and compressors with single-phase power. From ¾ to 5 hp.



G-E Type ACA induction motors for adjustable speeds—provide 3 to 1 speed range. From 3 to 200 hp.

YOU CAN'T BEAT

TRI CLAD

EXTRA PROTECTION

Clearsite containers molded of Styron by Cellaplastics Corporation, 50 Ave. L., Newark 5, New Jersey

...the plastic with the ~~PLUS~~ value!

specify STYRON

Mass production at low unit cost is the plus value STYRON *offers you.* That is why manufacturers specify STYRON (Dow Polystyrene) for a multitude of industrial and commercial applications. They are fully aware of the high quality of STYRON—its excellent adaptability and, above all, the fact that STYRON offers more pieces per pound.

STYRON proves its unique versatility in the mass production of the above shown containers. The use of STYRON affords these containers such sales advantages as: 75% lighter weight than conventional containers, crystal clear or gem-like colors, no danger of shattering, dimensional stability, uniformity and they are tasteless, odorless, acid and alkaline resistant. These STYRON containers are finding numerous applications in the drug and cosmetic fields.

The low cost and high quality of STYRON permitted its use in mass production. Let STYRON solve your production problem—contact Dow today for a competent molder to handle your specific problem.

DOW plastics

PLASTICS DIVISION, DEPT. T-21

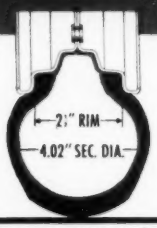
THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

New York • Boston • Philadelphia • Washington • Cleveland • Detroit • Chicago • St. Louis • Houston • San Francisco • Los Angeles • Seattle • Dow Chemical of Canada, Limited, Toronto, Canada

GENERAL
WIDE BASE
INDUSTRIAL PNEUMATICS
Save Time·Labor·Money

WIDE BASE	NARROW BASE
More Air Volume	Less Volume
More Load Capacity	Less Capacity
More Stability	Less Stability
More Cushioning	Less Cushioning

General Industrial Tire 16″ Overall Diameter on Wide-Base Rim.

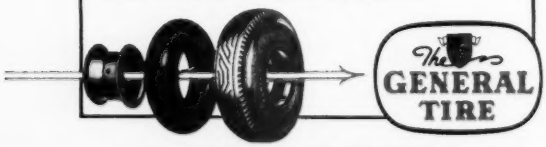


Conventional Tire 16″ Overall Diameter on Narrow-Base Rim.

For real savings . . . do as industries everywhere have done . . . *standardize* on wide-base General Industrial Pnuematics.

Heavier loads move easier, faster. Greater stability, less sway, easier steering, longer wear, lower worker fatigue. Big savings on floors and floor covering. Extra cushioning protects fragile loads and delicate mobile equipment.

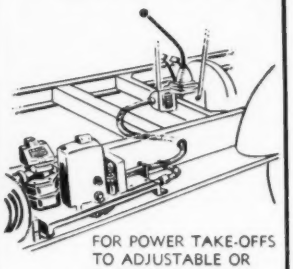
Two, four and six ply tires, sizes 8″ to 22″ O. D. available in complete assemblies of tire, tube and heavy-duty wheels. Ready for immediate installation on your equipment.



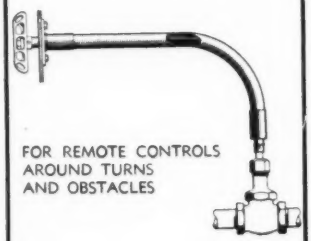
SEND FOR NEW CATALOG

Dept. A. THE GENERAL TIRE & RUBBER CO., Akron, O.

Elliott
FLEXIBLE SHAFTING



FOR POWER TAKE-OFFS TO ADJUSTABLE OR OUT-OF-LINE PARTS



FOR REMOTE CONTROLS AROUND TURNS AND OBSTACLES

Elliott
ENGINEERING AND DESIGN SERVICE

Backed by 50 years of experience in the Flexible Shaft and related fields, the Elliott engineering staff is constantly incorporating new and modern improvements in the design of their own equipment. This staff is available to you, as a part of the Elliott Service, to cooperate in working out the details of your own problems. We will be pleased to supply Flexible Shaft Data Sheets on request. These will aid you in furnishing us with certain necessary specifications such as r.p.m., torque, deflection, etc.

Write for Catalog 49 on your Company Letterhead

ELLIOTT
MANUFACTURING COMPANY
216 PROSPECT AVE. BINGHAMTON, N. Y.

Bundyweld*... your best call for tubing

Like to get a line on better design, faster production, lower costs or higher quality in your tubular applications?

Put in a call for Bundyweld* Tubing!

Double-walled from a single strip, bonded throughout, Bundyweld is lightweight, ductile . . . leakproof, too . . . and can be bent without fear of collapsing or weakening structurally. Held to close tolerances, it can be easily machined or fabricated . . . cuts production time, lowers production expense.

Manufacturers in many fields . . . automobile, machine tool, range, television, radiant heating, refrigeration, tubular toys—to mention only a few . . . are ringing in on the advantages of low-cost Bundyweld Tubing.

Chances are, your design, structural or functional problem can be solved by this miracle tubing of industry, even though you may not seem to need a tubing at all. Why not give it a try? Contact your near-by Bundy representative among those listed below, or write direct to: *Bundy Tubing Company, Detroit 14, Michigan.*

BUNDY TUBING

ENGINEERED TO YOUR EXPECTATIONS

* REG. U.S. PAT. OFF.

WHY BUNDYWELD IS BETTER TUBING

1 Bundyweld Tubing, made by a patented process, is entirely different from any other tubing. It starts as a single strip of basic metal, coated with a bonding metal.

2 This strip is continuously rolled twice laterally into tubular form. Walls of uniform thickness and concentricity are assured by close-tolerance, cold-rolled strip.

3 Next, a heating process fuses bonding metal to basic metal. Cooled, the double walls have become a strong ductile tube, free from scale, held to close dimensions.

4 Bundyweld comes in standard sizes, up to ⅝" O.D., in steel (copper or tin coated), Monel or nickel. For tubing of other sizes or metals, call or write Bundy.

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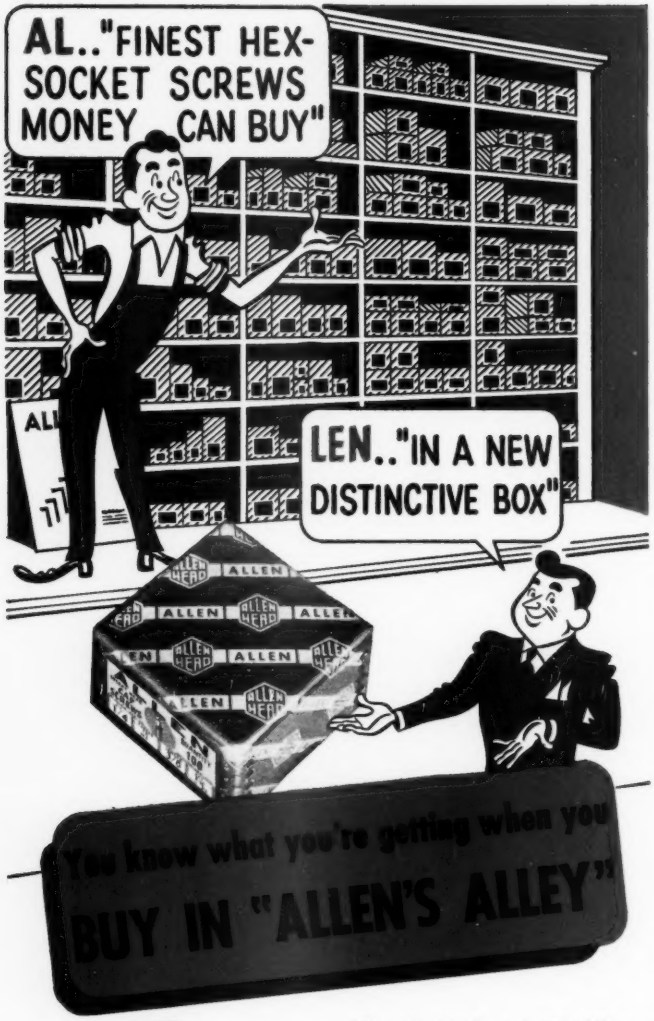
BUNDYWELD NICKEL AND MONEL TUBING IS SOLD BY INTERNATIONAL NICKEL COMPANY DISTRIBUTORS IN PRINCIPAL CITIES.


AL.."FINEST HEX-SOCKET SCREWS MONEY CAN BUY"
LEN.."IN A NEW DISTINCTIVE BOX"
ALLEN
ALLEN HEAD
You know what you're getting when you
BUY IN "ALLEN'S ALLEY"

If the shelves in your distributor's hex-socket screw section display row on row of the new, distinctive black box with the silver bands, you know you're getting *genuine Allens*, not just Allen-type hex-socket cap and set screws.

Allen stands for special Allenoy steels, for complete facilities for threading by any method, for the latest forming and heat-treating techniques, for quality control, and advanced engineering. You get all these advantages in one package, if you make sure that package is the new black *Allen* package with the silver stripes.

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BUYER'S MARKET

the new challenge to INDUSTRY

Yes, the buyer's market is back again in many product lines . . . sure to be back in all lines before this year runs out.

So now, when you are probably concentrating on redesigning *your* products to sell successfully in competitive markets, we think you'll want as much help as we can give you in *Designing for Lower Costs.*

The June issue of PRODUCT ENGINEERING will be completely devoted to this very important subject. Watch for it. This issue seems sure to set a new high mark in industrial publishing.

★

PRODUCT ENGINEERING

This little piggie went to market *in a wax overcoat*

. . . typical application of Honeywell Unitized Control!

Better wax packaging for food products is still another achievement of Honeywell Control Devices . . . the heart of one packer's system for protecting meat cuts prior to freezing.

Here, a single Honeywell *Unitized Control Panel* maintains complete control over the temperature of wax in a pre-heater *and* the temperature of the wax in the dip-tank. The controls, once set, are completely automatic—completely dependable.

Other applications for money-saving, time-saving Honeywell *Unitized Controls* are to be found in every industry and process, from dryers in laundries and dry cleaning plants to automatic coin vending machines and textile decating equipment—wherever there is need for multiple or complex control.

We invite inquiries concerning your control problems. Write for Instrumentation Data Sheet #11.0-1 for detailed information on the complete line of Honeywell *Unitized Control Panels*.

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BROWN INSTRUMENTS DIVISION
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Purebon

solves many problems

caused by sliding or rotating parts which are difficult or impossible to lubricate

A constantly increasing stream of problems are facing engineers and designers today involving sliding or rotating parts where lubrication is difficult or impossible. For such applications, Purebon, the mechanical carbon, is often the ideal answer. Typical applications are seal rings, bearings, pistons, piston rings, pump vanes, valve seats, meter discs, and a host of similar items. Purebon comes in a wide variety of grades. It is strong, tough, readily machineable and in many cases can be molded directly to size.

Bulletin No. 482 tells the complete story of Purebon. Write for your copy today.

PURE CARBON CO., INC.
448 HALL AVE. ST. MARYS, PA.

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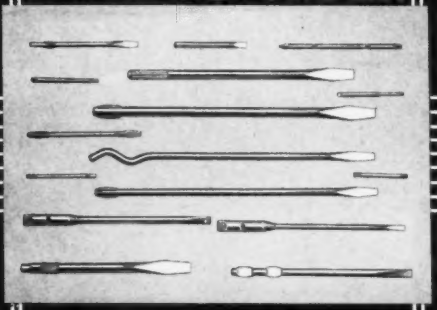


Screw driver blades to order for assembly in any type of handle, wooden, composition or plastic.

Points in either keystone or cabinet type. Edge of point carefully made and of uniform thickness.

Shanks are winged, fluted, formed or milled, as shown.

Blades furnished in plain finish, blued or nickle plated.

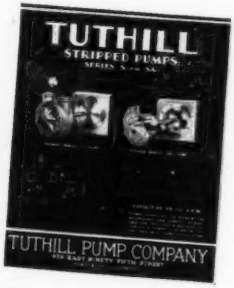
The Torrington Company
SPECIALTY DEP'T.
Torrington, Conn., U.S.A.

how to save space, material and money

By Using

TUTHILL

Stripped Pumps In Your Machinery Designs



You'll find many practical suggestions for incorporating the pump directly into the design of your equipment in this Tuthill Stripped Pump bulletin. It presents the two types of stripped pumps available, designed for lubrication, coolant, hydraulic and liquid transfer service. Capacities up to 200 g.p.m. Send for your copy today.

TUTHILL PUMP COMPANY
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HIGH TEMPERATURE STRENGTH?

LOOK INTO CROLOY

16-13-3

(TYPE 316)

SEAMLESS & WELDED

STAINLESS STEEL TUBING

FOR MECHANICAL USES

Available also in modified analyses 18–13–3 (Type 317) for extreme corrosion conditions, and 16–13–3cb (Type 316cb) for applications where heat-treatment after welding is impractical. Ask for Bulletin TDC-133 describing physical, mechanical and fabricating properties of these analyses.

TA-1467-S

BABCOCK & WILCOX SEAMLESS & WELDED TUBES

THE BABCOCK & WILCOX TUBE COMPANY
General Offices: Beaver Falls, Pa.
Plants: Beaver Falls, Pa., and Alliance, Ohio
A full range of Stainless, Alloy and Carbon Steel Tubing for all Pressure and Mechanical Applications

RUBBER . . . with a backbone of STEEL

LORD BONDED-RUBBER Products Solve Some of Industry's Toughest Design Problems

Rubber, bonded to metal by the LORD Process, gives the imaginative engineer what amounts to a new material with which to work—"rubber with a backbone of steel." Other metals, such as brass and dural, are also used to meet special conditions.

The characteristics of rubber, natural and synthetic,—its effective vibration control, its flexibility, its high coefficient of friction, its resistance to abrasion,—these qualities may be employed to fullest advantage because of the inseparable bond between the rubber and the substantial base to which it is attached.

Valve seats, motor mounts, idler wheels, diaphragms, pirn adapters, torsion joints, bearing seals, are a few of the successful applications which have been made and are suggestive of opportunities for improvement of other products. The Lord Bonded-Rubber Process combines the rigidity and strength of metal with the resiliency of rubber in a permanent bond that withstands strains and stresses of torsion, compression, or other distortion.

The greatest storehouse of practical experience in product improvement, through the application of rubber-bonded-to-metal, is at your service. Consult the Lord representative in your territory, or write

LORD MANUFACTURING COMPANY, ERIE, PA.
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LORD Vibration Control Systems

STRAND Quality Flexible Shafts

for Remote Control or Coupling

3/16" to 1 1/4" diameter dependent upon length

2" to 30' length dependent upon diameter

Strand top quality flexible shafts are important to those who are manufacturing quality equipment . . . They give an assurance of dependability, long life, and freedom from breakdowns. Used to couple, for remote control or mechanical regulation in hard-to-reach areas, they have proved successful over a period of years. They are available with or without coupling unit. They can also be had with or without casings. Special couplings made to order. N. A. Strand & Co., 5001 No. Wolcott Ave., Chicago 40, Ill.

STRAND
FLEXIBLE SHAFTS
AND FLEXIBLE SHAFT MACHINES

Standard X WASHERS

The Standard X Washer is an efficient, economical locking device. It provides quick, positive assembly . . . 360° closure to support greater thrust load . . . fast, easy removal . . . simplified service or repair. No vibration can shake it loose.

Standard X Washers are available for pin diameters from 7/32" to 17/32". For complete specifications write for Bulletin 26.

Standard
LOCKNUT & LOCKWASHER, INC.
311 N. CAPITOL AVE., INDIANAPOLIS 4, INDIANA

NEW C-D Silicone Dilecto withstands an inferno of heat and electricity

to improve product performance for you!

There are three new grades of C-D Dilecto* that can withstand temperatures as high as 250°C. They are chemically inert, silicone-glass laminated plastics that offer exceptionally high heat resistance and good arc resistance, extra strength, and positive moisture resistance! At Continental-Diamond we've literally lived and worked with Silicone Dilecto—perfecting it to a point where we believe it can be highly useful in helping to solve your production problems — and improve product performance.

And this remarkable plastic is but one of many in the C-D family. They provide practical combinations of mechanical, electrical, and chemical properties—structural strength, light weight, positive moisture, heat and corrosion resistance. In hundreds of plants, C-D Plastics—Fibre, Vulcoid, Dilecto, Celoron, and Micabond—offer proof that it pays to see C-D first in your search for the right plastic for the job. For interesting, useful information on Silicone Dilecto, and other C-D high strength plastics, call or write your nearest C-D office, soon.

your partner in producing better products

*Dilecto GB—112—S
Dilecto GB—128—S
Dilecto GB—261—S

DE-2-49

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WEST COAST REPRESENTATIVE: MARWOOD LTD., SAN FRANCISCO 3 • IN CANADA: DIAMOND STATE FIBRE CO. OF CANADA, LTD., TORONTO 8

Continental-Diamond FIBRE COMPANY

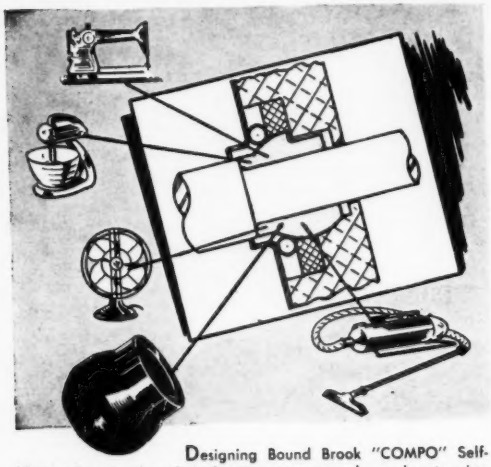
Established 1895 . . Manufacturers of Laminated Plastics since 1911—NEWARK 40 • DELAWARE

"COMPO" OIL-RETAINING POROUS BRONZE BEARINGS

Why Well-Known Electrical Appliance Manufacturers* Demand "COMPO"

FOR SELF-ALIGNING MOTOR BEARINGS

*NAMES ON REQUEST.



Designing Bound Brook "COMPO" Self-Aligning Bearings into their electric motors proved a real cost-saving way to insure motor-shaft alignment, less wear on parts, and smoother, quieter, performance. It also meant:

TO MANUFACTURERS • *Simplification of design; quicker, easier assembly* • *Elimination of oil cups, machining, drilling, tapping and grooving of the housing.*

TO USERS • *No periodic lubrication, quiet, trouble-free performance — under both continuous and intermittent operation.*

"COMPO" Porous Bronze Bearings are made from pure metal powders, die-formed to shape, alloyed at high temperatures, finished to exact dimensions, and vacuum-impregnated with lubricant. Self-lubricating qualities make them ideal for use in inaccessible spots. The lubricant is sealed in, free from dirt, and an even lubricating film is always present.

Thousands of "COMPO" Bearing sizes can be made from existing dies; hundreds of sizes in stock for prompt shipment. Mail the coupon below, to get our Stock List or arrange a conference with one of our engineers. *We've saved time and costs for others; we can do the same for you.*

Many other types of "COMPO" Bearings and "COMPO" structural parts have been designed into appliances and other types of equipment and machines at equal savings and with equal performance benefits.

BOUND BROOK OIL-LESS BEARING COMPANY

BEARINGS • BUSHINGS **WASHERS • PARTS**

BOUND BROOK, N. J. *ESTABLISHED 1883*

Bound Brook Oil-Less Bearing Co. PE 4-49
Bound Brook, N. J.

☐ I would like to talk to one of your engineers about _____

☐ Please send me a copy of your "COMPO" Bearing Stock List.

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Company _____

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YOU CAN'T BEAT FULMER HONING

● ***THE FASTEST,*** *most efficient* and easiest method of finishing cylindrical bores ½" to 30" diam.

● ***FAST STOCK REMOVAL:*** It is the common practice for stocks of .015"-.060" to be removed in a fraction of the time required to set up the job for boring.

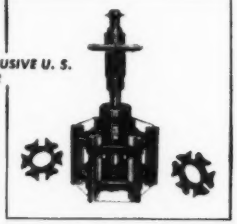
● ***EXTREME ACCURACY:*** Hold to ±.0001" tolerance on bore size, straightness, roundness, with any surface finish desired.

● ***ENGINEERED*** to give *maximum* production with *minimum* investment, Fulmer Honing Machines offer the *greatest value* in the honing field. Get full details today.

Fulmer Model 15-48 honing 12½"x42" Diesel liner .012"-.015" of Gun Iron is removed in 10-12 min. Machine capacity: 2"-15" diam.

FULMER COMPANY NOW EXCLUSIVE U. S. DISTRIBUTOR FOR ALEXANDER BALL HONING TOOLS

Available in sizes from ½" to 30" diam.



● **WRITE FOR NEW 12 PAGE HONING BULLETIN.**

Fully illustrated. Gives valuable data on honing applications, Alexander Ball Honing Tools, and specifications on all models of Fulmer Honing Machines.

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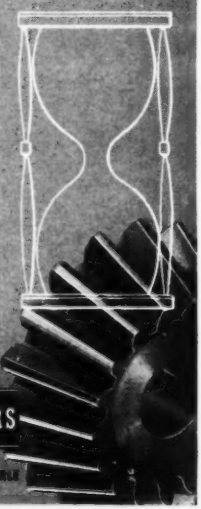
You can expect—and get—long trouble-free service and smooth, quiet operation from Earle Gears and Earle Operating Machinery.

Because Earle Gears are cut to extremely close tolerances to insure constant, uniform transmission of power through proper distribution of the load across the entire gear face. And, every Earle Gear is cut exactly to your specifications from whatever material best fits the application.

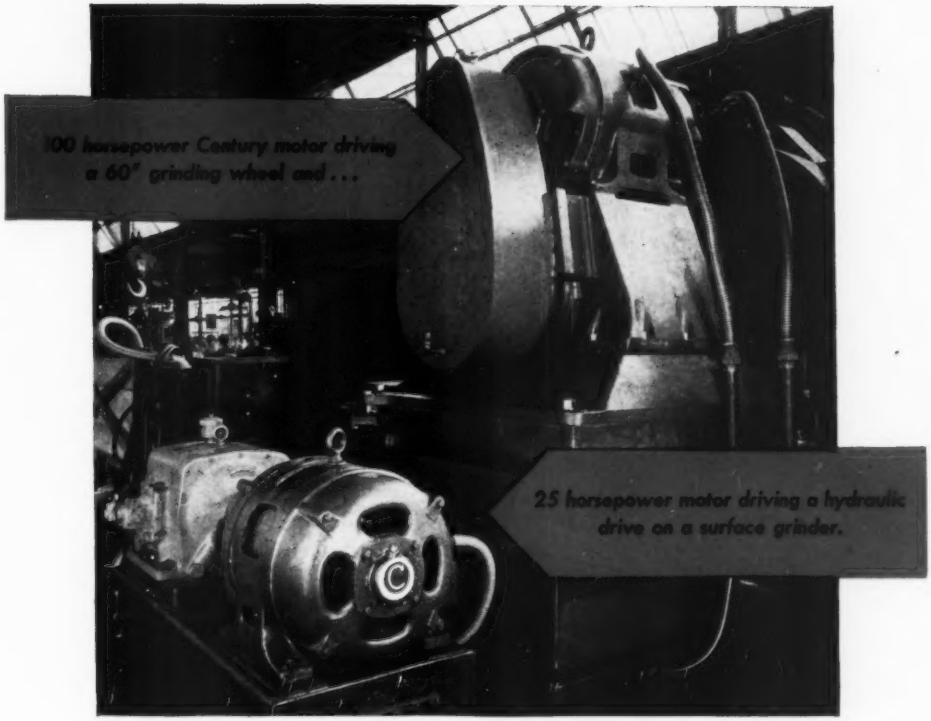
So, if you need gears, send us your drawings and specifications for quotation. You'll get immediate attention and prompt delivery.



THE EARLE GEAR & MACHINE CO., 4707 Stenton Ave., Philadelphia 44, Pa. Sales Offices: 149 Broadway, New York 6; 901 Davis Ave., Pittsburgh 12, Pa.; 7735 Market St., Youngstown, Ohio.

EARLE GEARS

It's good business to do business with EARLE


100 horsepower Century motor driving a 60" grinding wheel and . . .
25 horsepower motor driving a hydraulic drive on a surface grinder.

100 H. P. Century MOTOR—Driving a 60" Grinding Wheel Provides a Smooth Production Combination

This 100 H.P. Century Motor operating a huge 60" surface grinder and the 25 H.P. Century motor operating the feeder mechanism, is one of the hundreds of thousands of Century drives used in the precision production industries.

The unusual freedom from vibration designed and built into Century motors, contributes to the precision grinding at the business end of the grinder that was intended by the manufacturer of this fine tool.

The rugged mechanical design of Century motors are suitable not only to precision applications like this but also for the heavy shock loads required in some industrial operations.

From Century's wide range of types and kinds of motors, in sizes from 1/6 to 400 horsepower, you can select the correct motor to meet the exact requirements of your machines. The properly selected Century motor on your machine tools, conveyors, processing machinery, etc., helps to increase productivity, keep maintenance costs low and reduce plant shutdowns caused by improperly applied motors.

Specify Century motors for all of your electric power requirements.

Century C MOTORS

Popular types and ratings are generally available from factory and branch office stocks

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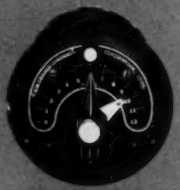
time as a factor of control in industry

Cramer

TIME DELAY RELAY



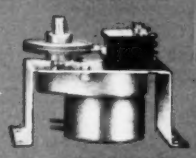
INTERVAL TIMER

RUNNING TIME METER

PULSE TIMER

PERCENTAGE TIMER

TYPE SX SYNCHRONOUS MOTOR



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If the performance of your product depends on precision timing, consult Cramer. As specialists in TIME as a factor of CONTROL, we have developed a wide range of devices to meet the needs of a great variety of commercial and industrial applications. Send today for detailed information.

THE R. W. CRAMER COMPANY, INC.
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2CR49

$1,500 inventory abolished —at a cost of $4.46!

With more than 700 vacuum tubes needed by industry, a tube distributor would find profits consumed by 100% inventories. But by ordering tubes as needed via Air Express, he holds stocks to 25%. Example: Orders $1,500 tube at 9 A.M. from supplier 900 miles away. Delivered to customer 6 P.M. same day. 16 lbs.: cost, $4.46.

Remember, $4.46 *included* speedy pick-up and delivery service, too. *More* protection, because you get a receipt for every shipment. Air Express is *world's fastest* shipping service.

Your Air Express shipments go by the Scheduled Airlines direct to 1300 airport cities; fastest air-rail for 22,000 off-airline offices. Shipments *keep moving* with 'round-the-clock service.

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19 lbs. of machine parts goes 600 miles for $3.54.
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Rates include pick-up and delivery door to door in all principal towns and cities

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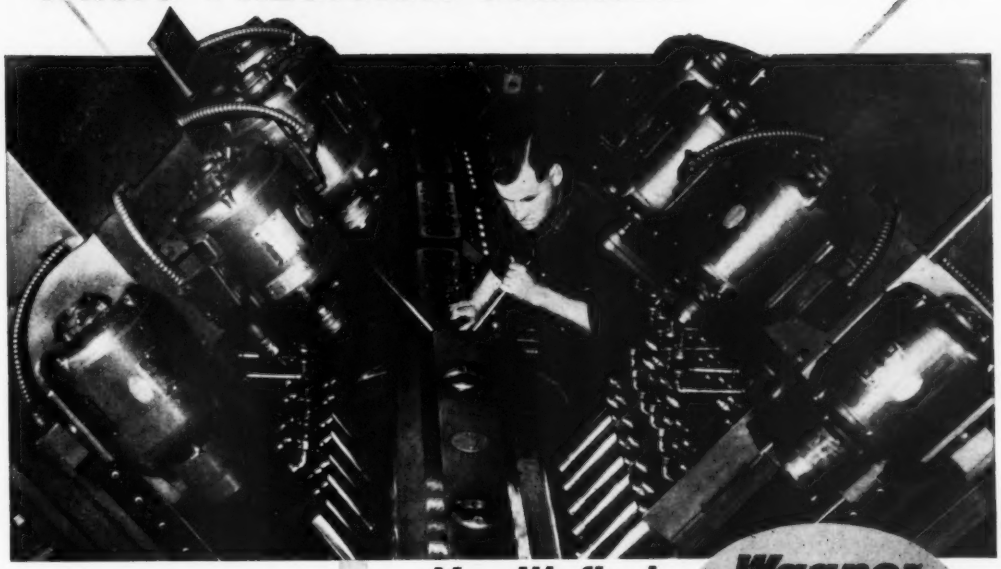
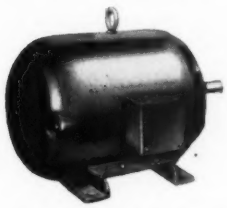
Where PRECISION *Counts...*



You'll find Wagner Motors on the job...

Totally-enclosed Non-ventilated Motor



Totally-enclosed Fan-cooled Motor

Real precision in a machine tool requires motors that operate smoothly, quietly and with minimum vibration. Wagner Motors are noted for these qualities and for long-lived dependability and economical operation as well!

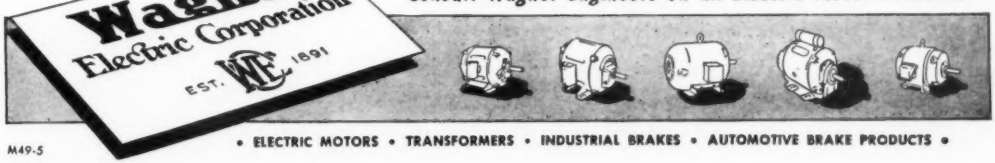
That's why Wagner Motors have been used extensively and are recommended by many widely-known machine tool manufacturers. If you want your machine tools and equipment to operate with precision, and with a minimum of costly "down-time"—choose Wagner Motors, too. Bulletin MU-185 gives information on the complete line of Wagner Motors. Write for a copy.

Buyers of Wagner Motors get Nationwide Service! More than 450 Wagner Authorized Electrical Service Stations and Parts Distributors augmented by 25 Wagner-owned Service Branches are ready to immediately supply on-the-spot service, factory guaranteed exchange motors, or genuine Wagner parts. Write for Bulletin MU-24 for complete list.

Wagner Electric Corporation

6406 PLYMOUTH AVE., ST. LOUIS 14, MO., U. S. A.

Consult Wagner Engineers on all Electric Motor Problems



M49-5

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This fine tough forging makes a fine TOUGH TOOL

You can hoe, weed and cultivate with this excellent new combination garden tool made by Fraim Co., of Norfolk, Virginia.

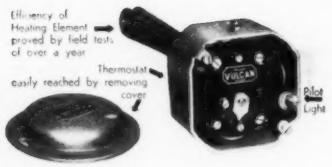
Not only is it efficient, but it is very tough because National drop forgings are made with exceptional skill. The fibre-like grain structure of selected steel is reinforced at areas of impact and greatest wear.

Our fine drop forgings offer tremendous strength and maximum fatigue resistance.

Write us today for booklets describing our standard line of SAE yoke and rod ends, container handles and knife blades, etc.:—and send us your inquiries for custom drop forgings.

• The Trademark "N" is your guarantee of Fine Quality Forgings.

THE NATIONAL LOCK WASHER CO.
DROP FORGING DIVISION
NEWARK 5 **NEW JERSEY**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Thermostat easily reached by removing cover
VULCAN
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Economical Hot Water ELECTRICALLY with this new VULCAN Immersion Heater

THERMOSTAT can be set for any desired temperature. No danger of overheating.

EASILY INSTALLED by simply inserting in tank or boiler and connecting to the nearest convenient outlet. *The one inch tapered pipe thread fits standard domestic type hot water boilers.

FLEXIBLE Permits placing small tanks where hot water is to be used.

PRACTICAL for wash rooms . . . or anywhere in factories, stores, offices or institutions where hot water is needed.

CAN BE USED with present hot water system without disturbing existing piping.

* Or 1¼" if desired.

By the makers of Vulcan Electric Soldering Tools, Solder Pots, Glue Pots and Branding Irons.

VULCAN ELECTRIC CO.
DANVERS 18, MASS.

A RUGGED PAIR!

Correctly Applied
...that's the
VIKING ROTARY PUMP

The sturdiness built into the Viking rotary pump is well illustrated in the Viking rotor and idler above. Their wide tooth form and slow operating speed result in efficient operation, with long, dependable service.

This original "gear within a gear" design, most copied of all rotary pump principles, is the key to good pumping. Look to Viking for the correctly engineered pump for your job.

Send us your pumping problem today and ask for bulletin 49SX. Both problem and request will be given immediate attention without obligation to you.

See Our Catalog In SWEET'S

Viking PUMP COMPANY
Cedar Falls, Iowa

WHEN CORROSION RESISTANCE AND HIGH STRENGTH ARE ESSENTIAL . . .

Tuf-Stuf

IS OFTEN THE SOLUTION

TUF-STUF is the Mueller Brass Co. trade name for Aluminum Bronze. It is furnished in a series of five different alloys, depending upon the purpose for which it is intended.

PROPERTIES

The outstanding properties of TUF-STUF are wear resistance—corrosion resistance—high strength over a wide range of temperatures (sub-zero and elevated)—high brinell hardness on the heat treatable type of alloys—ability to withstand shock—high compressive strength and resistance to fatigue—lighter in weight than other copper base alloys.

SOME OF THE MANY APPLICATIONS OF TUF-STUF

Gears • Worm Wheels • Bushings • Bearings • Lead Screw Nuts • Valve Seat Inserts and Spark Plug Inserts in airplane engines • Shifter Forks • Valve Stems • Rocker Arm Bushings • Tie Rods, Nuts, and Washers for pickle tanks • Window Bolts • Parts in contact with steam, brine, sea water, weak acids and alkalis, crude oils, disinfectants, plant sprays.

TUF-STUF Alloys are not susceptible to corrosion cracking. TUF-STUF Alloys are furnished in the form of forgings, rods and screw machine parts.

If you have a metal problem, TUF-STUF may be the answer. Let us send you complete literature on all Mueller Brass Co. alloys with their physical and chemical properties and uses. Write for catalog 3-A.

MUELLER BRASS CO.
PORT HURON, MICHIGAN

For low-cost performance of

INDUSTRIAL RUBBER PRODUCTS

. . . use these tested design techniques

HERE'S a handy reference that gives you a thorough analysis of all important factors you must take into account when working with rubber in industry. Whether you're an engineer—designer—shop superintendent—industrial technician—no matter what your link with the rubber field . . . you'll find this concise treatment of the physical and chemical properties of rubber compounds a handy and practical guide.

JUST PUBLISHED!

ENGINEERING WITH RUBBER

Edited by Walter E. Burton

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461 pages, 445 illustrations, $6.50

THIS reference book gives you the practical **engineering, application, maintenance** and **design** principles of molded, extruded and lathe-cut rubber, hose, gaskets, belting, and scores of other rubber parts used by industry. It illustrates uses for American-made rubbers, crude and reclaimed rubbers and rubber-like materials . . . presents a complete picture of the physical and chemical properties of rubber compounds, the typical dimensions and structural details of industrial rubber products.

This guide shows you how to reduce vibrations with rubber mountings—how to determine when extruded rubber parts can be used—how to use packing and sheet rubber, etc. Its tremendous store of useful information is ready to help you find the right answers, the first time, to your specialized design and construction problems.

Stage-by-stage procedures show you:

- how to select and use rubber adhesives
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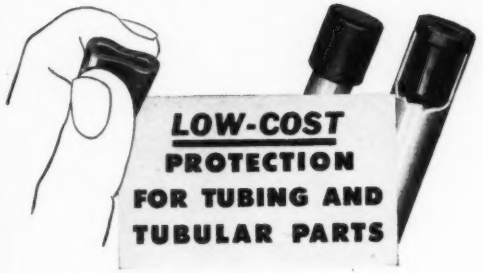

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PLUGS and CAPS

Slipped into or over the ends of plain tubing, these plugs and caps protect the ends and keep out dirt and moisture.

Made of flexible Vinylite plastic, they are resistant to most oils, offer high electrical insulation, and are easily applied and stay put. For details

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THE S. S. WHITE DENTAL MFG. CO. — DEPT. DP, 10 EAST 40th ST., NEW YORK 16, N. Y.

FLEXIBLE SHAFTS AND ACCESSORIES
MOLDED PLASTICS PRODUCTS—MOLDED RESISTORS

TOUREK BALL JOINTS and SCREW MACHINE PRODUCTS

BALL JOINTS

Many manufacturers find that in Tourek's wide range of standard Ball Joints there is a type and size which meets their exact requirements. You, too, can simplify the design and improve the performance, as well as reduce the cost of your products by specifying standard Tourek Ball Joints . . . Our large stock assures prompt delivery.

Or, if you are planning a new product calling for special Ball Joint design, call upon Tourek for experienced advice.

Write for Tourek's 16-page illustrated catalog, containing complete specifications on 12 standard types in 54 sizes as well as data on special types.

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Your screw machine product requirements, when produced at Tourek, are the result of coordinated engineering know-how, the latest in modern high-speed 6-spindle automatics, skilled operators, plus 28 years of experience.

Your production parts, from 1/8" to 2 3/8" are made with the utmost precision and delivery is assured according to schedule.

An inquiry on your screw machine product needs is invited. Send a blueprint or sample for quotation.

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TOUREK
FAMOUS BALL JOINTS

To generate electricity for transmitting messages, the telegraph industry relied on batteries. Cells of the gravity battery were cumbersome jars — 12 in. high, 8 in. across. By 1893, finding space for thousands of jars threatened the industry's expansion. Crocker-Wheeler, oldest electric motor manufacturer, designed and built motor-generator sets. Each, occupying a space two ft. square, did the work of 500 of the old cells which took up more than 222 sq. ft.

When the Telegraph Industry escaped from GLASS JARS...

CROCKER-WHEELER
made motor news

TODAY, 55 years and over a million motors later, Crocker-Wheeler no longer concentrates on the design and manufacture of special motors exclusively. But the pioneering spirit and engineering skill of Crocker-Wheeler that persuaded industry to adopt electricity half a century ago are still very much alive—in the performance of C-W standard motors today.

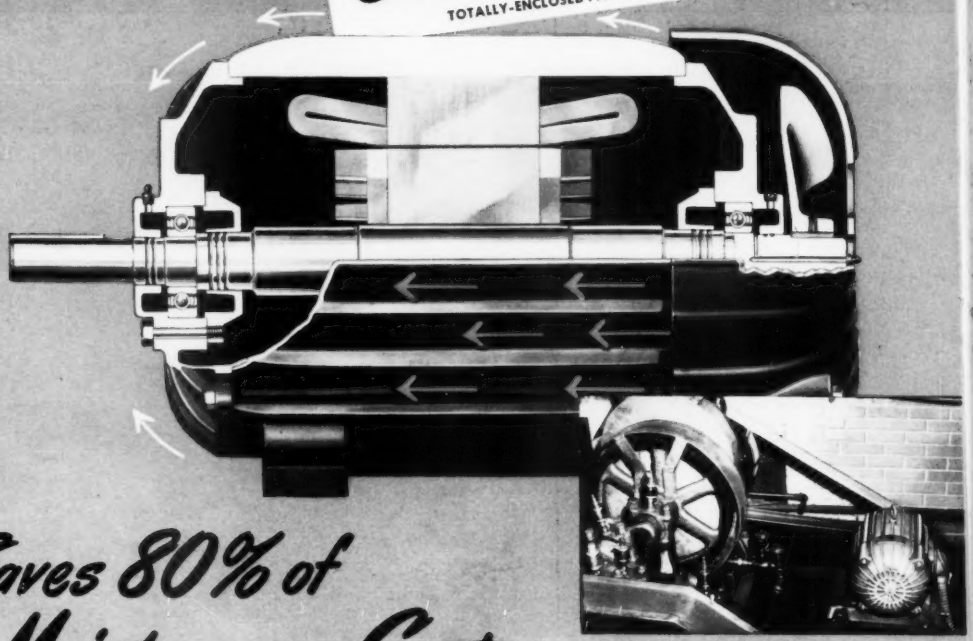
Past and present (yes, and the future) are inseparably fused at Crocker-Wheeler. A high percentage of the skilled workers who helped C-W make motor news through the years are still on the job, bringing to motor problems of modern industry a rare background of knowledge and engineering experience.

You'll understand what we mean (if you don't already know) as new, more efficient standard motors, developed by Crocker-Wheeler, are introduced in 1949. You can sense it just by *talking* to Crocker-Wheeler when you have a difficult motor problem. Here, you will say, is a master of the art of motor-making—but more than that, the kind of organization with which you would like to do business Crocker-Wheeler Electric Manufacturing Company, Ampere 3, N. J.

AND CROCKER-WHEELER IS MAKING MOTOR NEWS TODAY

CROCKER-WHEELER *Sealedpower* MOTOR

TOTALLY-ENCLOSED . . . FAN-COOLED



Saves 80% of Maintenance Costs

Sealedpower Motor driving a vertical triplex power pump where moisture is excessive.

You can make maintenance savings of 80% and *more* with Crocker-Wheeler Sealedpower Motors. The secret? C-W dollar-saving design. No other totally-enclosed, fan-cooled motor has *exterior* cooling, with the fan-driven airstream blowing over a finned frame, carrying dust and fumes *outside* and *away*. (The outside fins that identify a Sealedpower Motor provide over 150% more cooling surface.)

But that's not all — this motor keeps cooler longer because it keeps cleaner. There's no place for lint or dirt to *collect* . . . nothing to hold heat *in*. Even on the really dirty jobs, a Sealedpower Motor will keep production going many times longer than "ventilating passage" motors, without a shutdown for cleaning.

For years of cool, clean operation and low maintenance cost, specify Sealedpower Motors. They're stock motors made for the toughest service. In new ratings from 3 to 60 hp.

Crocker-Wheeler Electric Manufacturing Company, Ampere 3, N. J. Division of The Joshua Hendy Corp., Branch Offices: Boston, Buffalo, Chicago, Cincinnati, Cleveland, Los Angeles, Milwaukee, New York, Philadelphia, Pittsburgh, San Francisco, Washington, D. C. Representatives in principal cities.

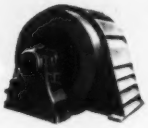
SEND FOR BOOKLET, "It's Different — it's a Dollar-Saver." Tells why the Sealedpower Motor will save money for you.

WHATEVER YOUR MOTOR REQUIREMENTS — CALL ON CROCKER-WHEELER

If Crocker-Wheeler builds it, it's a better built machine.

Horizontal and Vertical Protected-Type Induction Motors

A-C Generators and High Speed Synchronous Motors



Large D-C Motors and Generators

Turbogenerators

CROCKER WHEELER

ELECTRIC MANUFACTURING COMPANY, AMPERE 3, N. J.

Division of Joshua Hendy Corporation

OPTICALLY CLEAR PLEXIGLAS WEIGHS 52% *LESS* THAN GLASS!

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Think what you can do with this sparkling acrylic plastic—in merchandise and merchandising. In small products or components, in large items like sign faces, skylights, showcases, in a thousand-and-one industrial and building applications, PLEXIGLAS speeds production and whittles costs.

Its easy workability, resistance to sun and weather, gleaming brilliance, color possibilities and ability to "pipe" light make it *the* plastic for indoor or outdoor use.

Our new booklet suggests how PLEXIGLAS can add new lightness, new beauty, new durability to your products. Send for your copy today.

CHEMICALS FOR INDUSTRY

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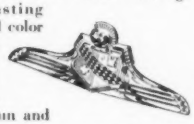
PLEXIGLAS *is a trade-mark, Reg. U. S. Pat. Off.*

The Final Touch for beauty ...for comfort...for safety

PLEXIGLAS FOR TODAY'S CARS

1. Crests for the new Buicks, molded of PLEXIGLAS V-100 molding powder. Lasting brilliance and color distinguish them because easily-molded PLEXIGLAS is immune to sun and weather—even after years of wear.



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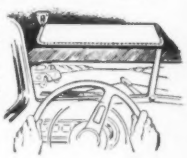
2. Robbins Full-view rear windows of PLEXIGLAS increase rear-vision in convertibles nearly 500% over most fabric-and-glass panels. Strength and resilience provide safety. Light weight permits easy installation.

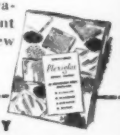
* * *

3. Optically true Visilite Sun Visor of smoky green PLEXIGLAS cuts sun heat and glare of sky, road and bright light to a minimum. No frosting because visor is installed flush against upper inside surface of windshield.



* * *

For decorative parts and functional accessories that add the final touch to any car—use PLEXIGLAS. We'll be glad to give you complete details. Write as fully as you wish regarding specific applications, or use the convenient coupon to ask for our new PLEXIGLAS brochure.



ROHM & HAAS COMPANY

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Please send us your booklet, "PLEXIGLAS—AN OUTSTANDING MATERIAL FOR PRODUCTS REQUIRING STRENGTH, PERMANENCE, LIGHT WEIGHT, BEAUTY."

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WHAT'S NEW IN AUBURN Plastics

SELF-HINGED BOX. A new and completely different kind of package is molded by AUBURN to hold the parts of a button-hole attachment made by the Greist Mfg. Co., New Haven, Conn., for the Singer Sewing Machine Company.

Developed by AUBURN and designed by Egmont Arens, it is injection molded of polyethylene as one self-hinged unit. The "built-in" hinge gives a spring action when opening and closing the box . . . is tested up to 70,000 openings and closings without appreciable wear.

Inherent advantages of the new box provide a wide range of packaging applications. It is soft . . . protects stored parts against damage. It is pleasing to see and feel . . . can be grained to simulate leather or given any other surface design . . . easy to clean and keep clean. Has unlimited possibilities as a re-use package!

• • •

CLARINET CASE. An improved type of reinforced plastic gives increased utility and durability to the clarinet case molded by AUBURN for the Komold Case Co. of Philadelphia.

The new material is made of sisal fibre bats with a binder of polyester resin. It gives the case an impact strength of 10 foot lbs. (Izod) . . . Fiberglas, decorative papers and other combinations can be used. Abrasion resistance, light weight and unusual pleasing appearance are among its other advantages.

AUBURN research engineers have just completed the development and final testing of this new reinforced plastic which has special applications for housings, covers, and other shapes with compound curvatures where weight-strength ratio is important . . . and where wall thickness is uniform.

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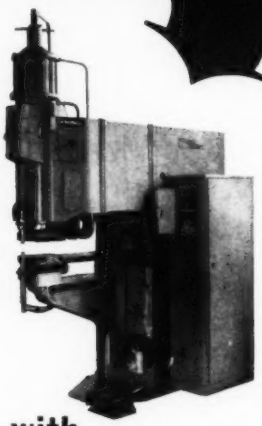

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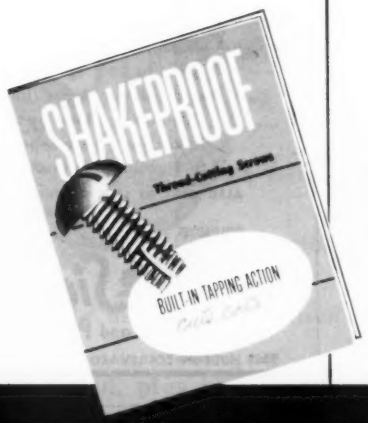

Type 1 Shakeproof Thread-Cutting Screw – ideal for a wide range of steels, stainless steels and the harder alloys.

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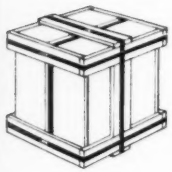

Yes, the best way to find out everything you want to know about a motor is to test it out for yourself. Put it to work on the toughest kind of jobs that come your way. Test it under all kinds of conditions.

That's why we want to make it easy for you to get and use a K-C Motor.

All you need to do is to write and tell us you'd like a sample K-C Motor. We'll ship it out to you right away. We will bill you for it but with the clear-cut understanding that you can return it *for full credit* at any time within six months, regardless of the motor's condition.

We make this offer because we are so sure of the K-C Motor's ability to give you smooth, quiet operation even under difficult conditions and continuous operation. But we want you to find it out for yourself. Write us today!

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Kingston-Conley Division
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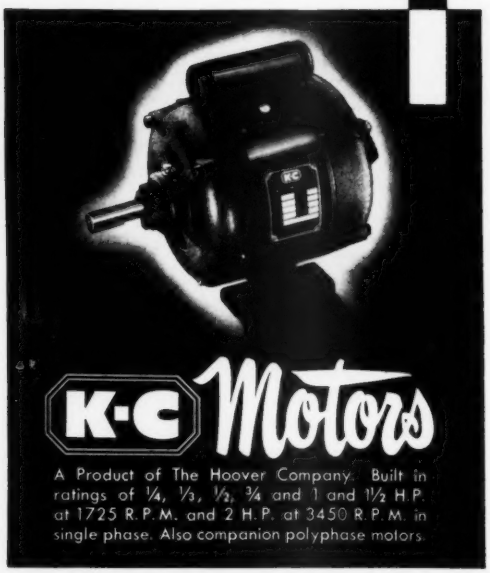

K-C Motors

A Product of The Hoover Company. Built in ratings of ¼, ⅓, ½, ¾ and 1 and 1½ H.P. at 1725 R.P.M. and 2 H.P. at 3450 R.P.M. in single phase. Also companion polyphase motors.

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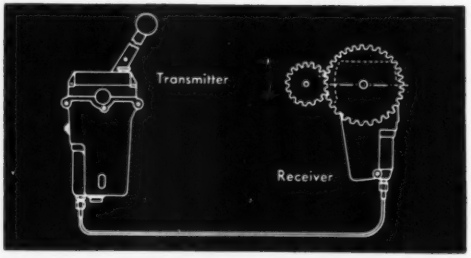
Gear drive on SPERRY
HYDRAULIC REMOTE CONTROL
*will amplify or reduce 55° operating arc**



Putting gears or pulleys on receiver shaft of Sperry Hydraulic Remote Control permits great variation of its effective operating arc. This makes possible more accurate control of valves, indicators and similar equipment. Torque output depends on gear ratios employed.

Sperry Hydraulic Remote Control provides accuracy to ¼ of 1°. It is moisture-and-dust-resistant. Automatic synchronizing valve compensates for volumetric changes in fluid due to temperature change.

For all the facts on Sperry Hydraulic Remote Control, write today for Bulletin 2001-I-4.

*Gears are not supplied with controls.

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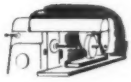
NO SOAP!

This designer of power tools had a brain wave .. Why not scoop competition with a featherweight portable electric drill . . . using a cast magnesium housing? But the boss said, "No soap! Too tricky to machine." Undaunted, the designer got in touch with Aluminum Company of America, light metal headquarters . . . He found that simple shop practices  make handling magnesium no problem*. . that every month industry successfully uses over a million pounds of this modern metal. He got valuable technical aid, plus books on designing and fabricating magnesium. From then on, it was a cinch to sell his boss on switching to light, strong, easy-to-machine American Magnesium Castings. Now he's the fair-haired boy at the plant since his magnesium hunch put new sales appeal into their whole line.

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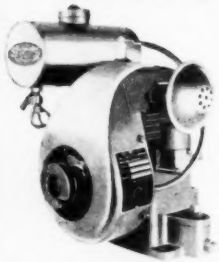

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Evaluates Practical Uses in Many Fields

Brought out of the research laboratory and into industry, ultrasonics has tremendously broad, practical applications. This guide points the way to greater use of ultrasonics in, for example, MATERIALS TESTING: to detect flaws in metals, plastics and glass, etc.; CHEMICAL INDUSTRIES; to make better mixtures and emulsions, etc.; METALLURGY: for extremely uniform mixtures free of air bubbles, etc. It likewise discusses experimental applications to systems of television, underwater signaling, depth sounding, communication, destruction of bacteria, etc.

CONTENTS

1. Ultrasonic Waves
2. Ultrasonic Waves: Further Theory
3. Crystals for Ultrasonic Use
4. Crystal Holders for Ultrasonic Use
5. Resonance and Reflection
6. Continuous-wave Ultrasonic Systems
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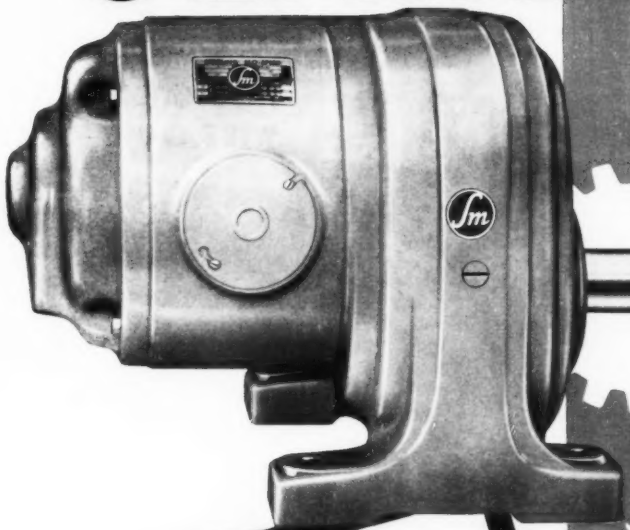

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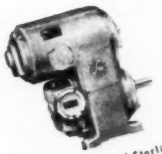
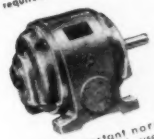
Improved Sterling Slo-Speed geared motors are available with single and double reduction gears in a wide variety of ratios.



Use the improved Sterling Speed-Trol—where "speed control"—faster or slower—is required.



Where constant normal speed is required, use the Improved Sterling KLOSD-TITE FAN-COOLED; KLOSD-TITE ENCLOSED; KLOSD-FACE MOUNTED electric power drives.

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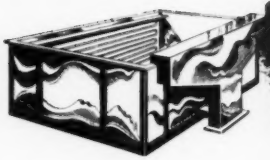
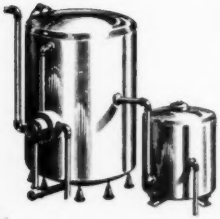
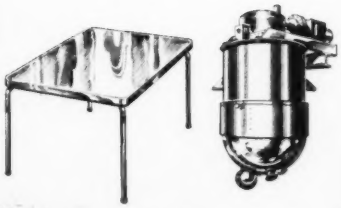


WHEN
CORROSION RESISTANCE IS ESSENTIAL

BU[illegible] IT WITH
PERMACLAD
STAINLESS CLAD STEEL





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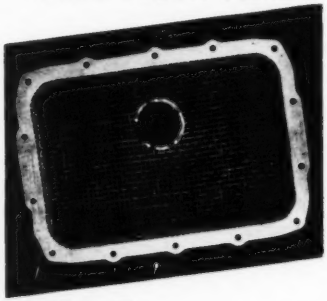

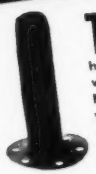

The manufacture of high quality fabricated woven wire parts is a Newark specialty. If you use screens, filters or strainers in your product, Newark offers the reliability of a "start to finish" responsibility. We manufacture the wire cloth thus assuring uniformity of the finished fabricated part.

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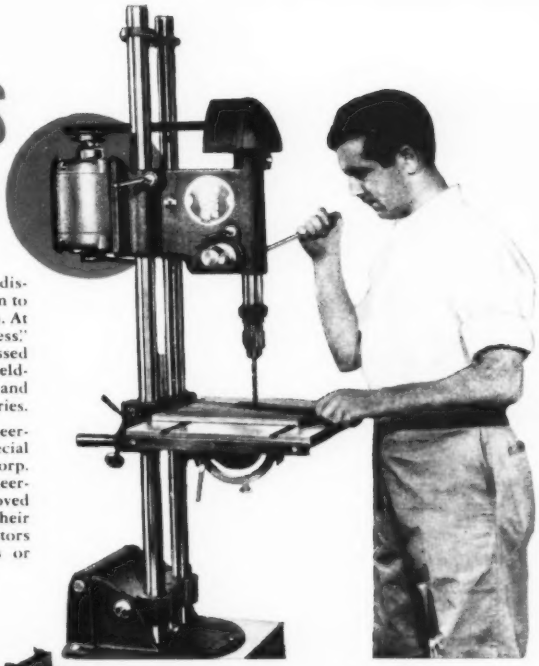
A.O. Smith Builds ELECTRIC MOTORS

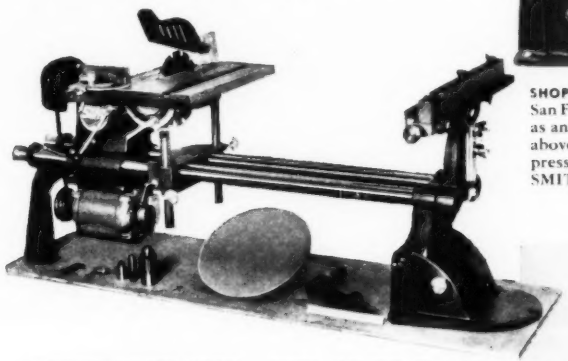
for hundreds of products including the multi-purpose "Shopsmith"

A. O. Smith's research and engineering staff is at your disposal to help integrate motor design with product design to achieve the most efficient and economical operation. At A.O. Smith, research and engineering is itself a "big business." Out of its 75 years' experience have come the first pressed steel automobile frame ever built, the first heavy-coated welding electrode, the first glass-lined water heater tank, and many other new products serving a large number of industries.

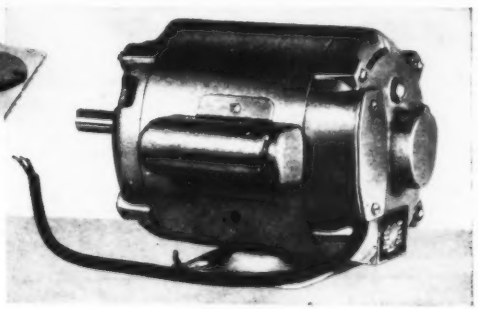
Typical of the problems A. O. Smith has solved in engineering electric motors to fit product requirements is the special "Shopsmith" design developed for Magna Engineering Corp. A. O. Smith also extends its complete research and engineering facilities to other manufacturers seeking improved performance or requiring unusual characteristics in their component power equipment. SMITHway Electric Motors can be built either to your particular specifications or furnished in a full range of standard sizes.



SHOPSMITH, product of Magna Engineering Corp., San Francisco, is a 5-in-1 shop tool that can be used (left) as an 8" saw, 12" disc sander, 34" lathe, and (as shown above) a 15" vertical drill press and as a horizontal drill press with no limit on work length. Powered with SMITHway Electric Motor.



SMITHway ELECTRIC MOTOR, shown here reversed from its mounted position on the "Shopsmith," is a capacitor-start, single-phase, ½ HP motor, 1725 rpm, 115 volts. Double-shielded, prelubricated ball bearings, rolled steel frame, welded steel base for ceiling mount.



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The A. O. Smith Product Service Division provides fast, low-cost motor service to more than 200 authorized service stations, on a 24-hour, off-the-shelf basis. Factory Service Branches and Warehouses at Union, N.J., Chicago, and Los Angeles.

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PLENTY OF FLEX BUT NO PERMANENT SET in this fishing rod made by Penrod Company. Beryllium-copper Tubing welded and drawn by Superior Tube Company.

Are YOU Looking for Properties the Fisherman Gets In This Rod Made of BERYLLIUM-COPPER?

and in addition —

STRENGTH AND HARDNESS. BERYLCO 25S, a readily machined and formed alloy, attains the highest strength and hardness of any nonferrous material through a simple, low-temperature heat-treatment after fabrication. Moderately cold-rolled strip, which can take a 90 degree bend about a radius equal to stock thickness, reaches an ultimate tensile strength of 180,000 psi after heating for two hours at 600°F. The following table shows typical values for available tempers of BERYLCO 25S strip:

Strip Tempers	Tensile Strength	Elongation	Elastic Limit	Rockwell Hardness
Before Heat-Treatment				
Annealed	70,000	35	20,000	B60
1 No. Hard	80,000	10	35,000	B75
2 No. Hard	90,000	5	50,000	B90
4 No. Hard	100,000	2	60,000	B95
After Heat-Treatment				
Annealed	170,000	6	80,000	C37
1 No. Hard	180,000	4	90,000	C39
2 No. Hard	190,000	2	100,000	C41
4 No. Hard	200,000	1	110,000	C43

CORROSION RESISTANCE. Having the inherent corrosion resistance of copper, BERYLCO 25S is dependable in marine and industrial atmospheres without the addition of protective coatings which may abrade or crack in use. Beryllium-copper also is unaffected by "season cracking" and hydrogen embrittlement.

CORROSION-FATIGUE AND ENDURANCE. BERYLCO 25S offers the highest corrosion-fatigue strength of any good spring material, showing no loss of endurance in a salt spray. It is widely used in diaphragm and spring applications requiring long life. Typical endurance values for cold-worked and heat-treated material are given below:

Strip—in reverse bending	40,000—50,000 psi
Rod—rotating beam Wire—rotating arc compression spring	45,000—60,000

ELECTRICAL AND THERMAL CONDUCTIVITY. Heat-treated BERYLCO 25S has a conductivity of 23 to 30% that of copper. This, combined with excellent spring properties, accounts for its successful use in many current-carrying applications.

For more information as to how BERYLCO 25S furnished as rod, strip or wire, may solve your design problem, write to us today, giving full particulars.

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3 BILLION DOLLARS EVERY YEAR

The annual toll taken by the elements that cause rust and corrosion is staggering. How much of this are you *needlessly* paying in costly replacement and maintenance *because you didn't* provide protection for exposed installations and equipment?

Hot-Dip Galvanizing Seals in the Base Metal

When base metal is encased in rust-preventing zinc by the Hot-Dip Galvanizing process the ravages of rust and corrosion can't touch the metal because it is *sealed in.* Rust and corrosive elements are *sealed out.*

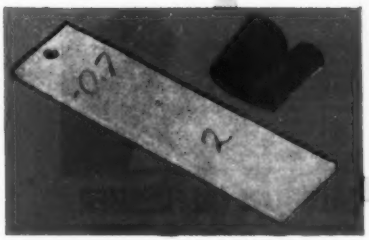
Write for Membership Roster

Every member of this Association has the cumulative experience of the entire membership at his disposal. He has the most modern equipment and a trained organization that are at your service. For membership roster, write The Secretary, American Hot Dip Galvanizers Association, Inc., First National Bank Building, Pittsburgh, Pa.

hot-dip GALVANIZING

IT'S ALL FOR THE GOOD OF SIRVIS...

THE BOIL TEST



Boiling would be rugged treatment for any steer. But, for Sirvis steer*hide* it's a must. The boil test, which is more severe than either dry heat or hot oil tests, determines heat resistance, measured by shrinkage. Because of Sirvis tanning processes, shrinkage under the boil test is usually less than 1%. Sirvis' reaction to the test is demonstrated by two pieces of buff grain steerhide, identical in quality and dimensions. After boiling in the same container for thirty minutes, one piece, an ordinary vegetable tanned leather, was hard, curled and shrunken, as shown in the photograph. The Sirvis chrome retanned piece shrank only 0.7% . . . retained its natural flexibility, strength and texture . . . and its resistance to heat was thereby accurately determined.

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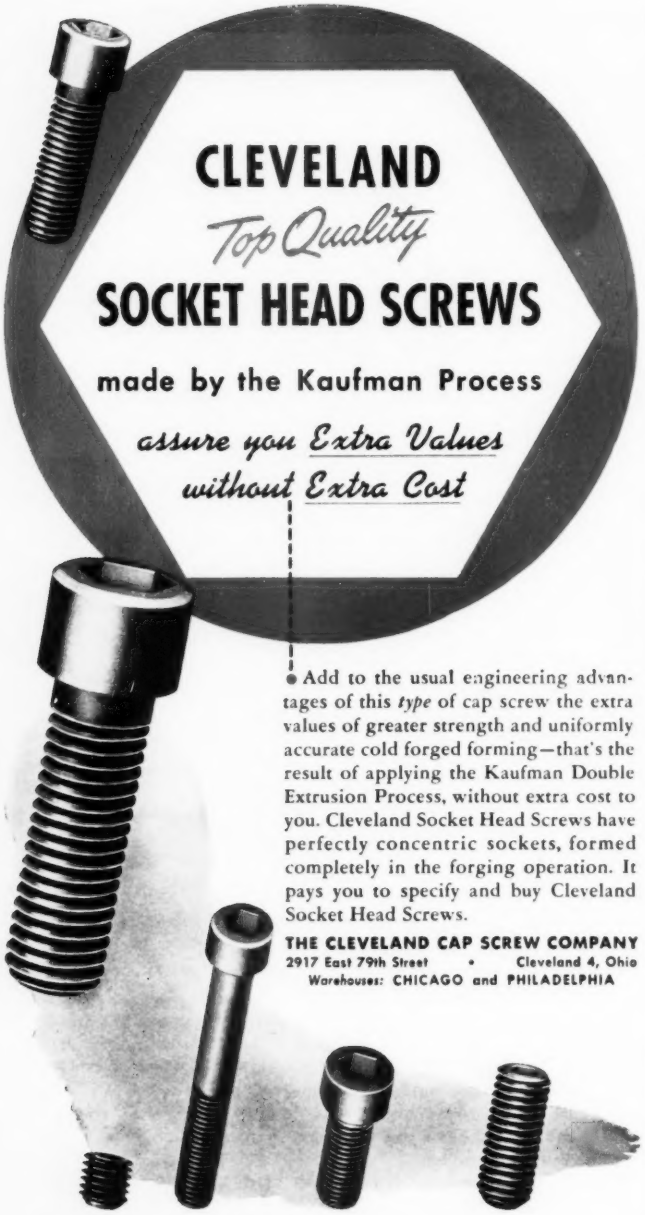

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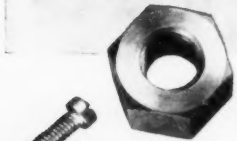

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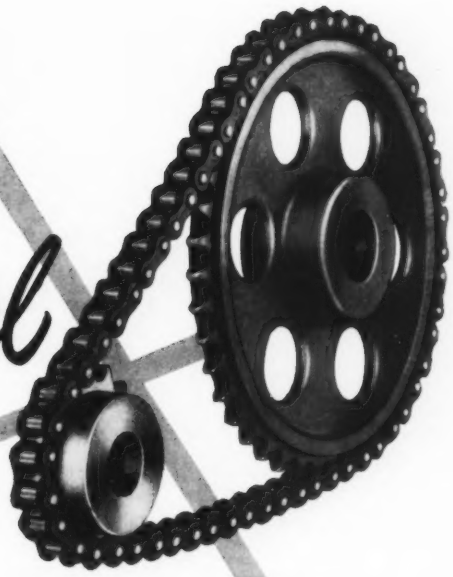

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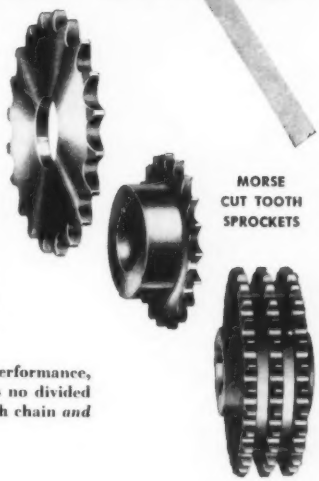

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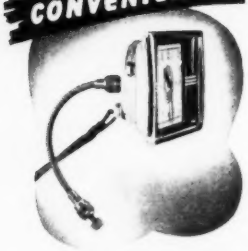
◀Versatility is well illustrated by the use of flexible shafts as spindles in this multiple spindle drill press. Besides providing a powerful, positive drive, the shafts permit quick regrouping of the spindles to meet various drilling requirements. *Courtesy of General Gas Light Co., Kalamazoo, Mich.*

CONVENIENCE



◀As for convenience, consider this automobile clock application. An S.S. White remote control flexible shaft connected to the clock reset spindle allows the control knob to be placed in an accessible operating position no matter where the clock is mounted.

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◀The adjustable features of the flexible shaft drive are hard to beat. In this power saw, for instance, the flexible shaft makes it possible to set the blade in almost any desired cutting position. *Courtesy of Flexsaw Mfg. Co., Port Austin, Mich.*

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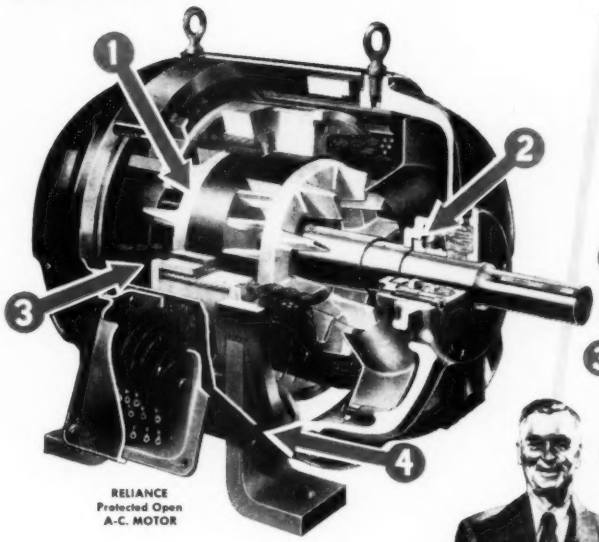

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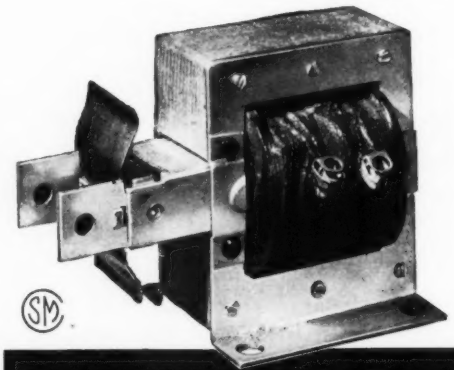

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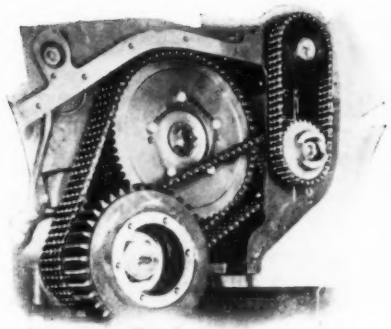

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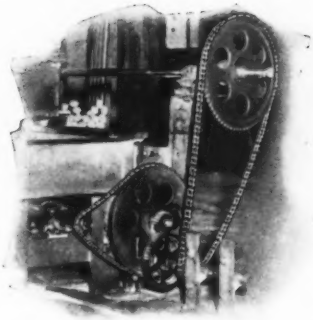

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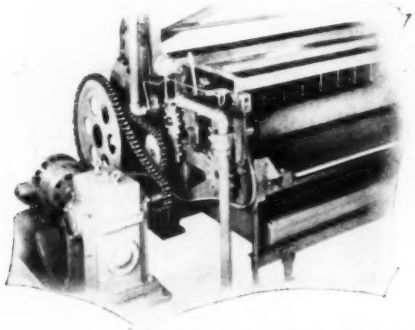

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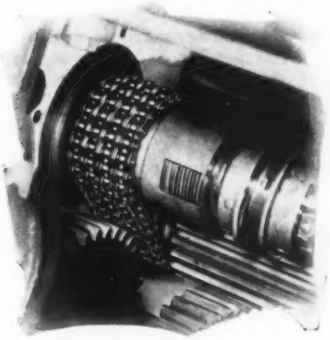

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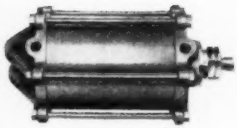

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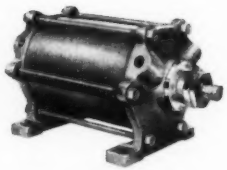

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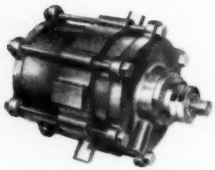

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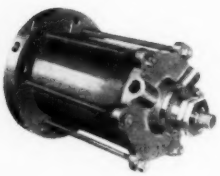

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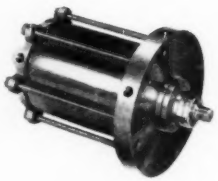

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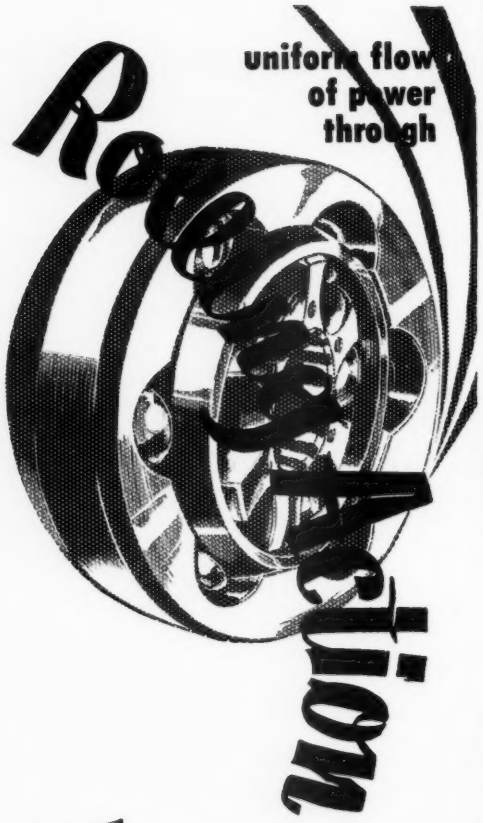

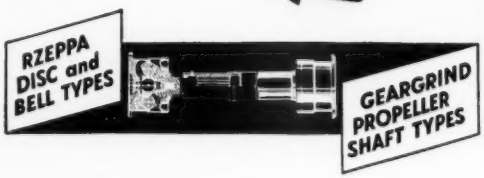

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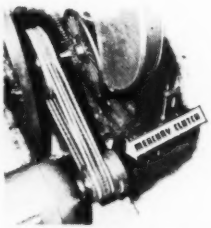

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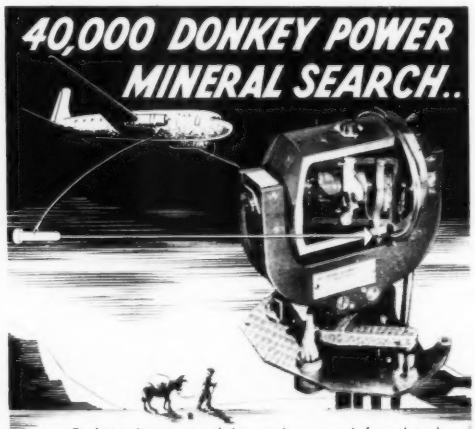

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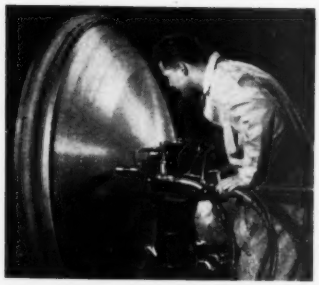

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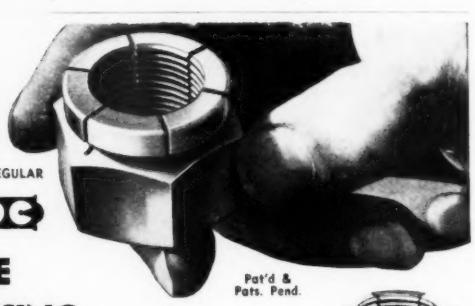

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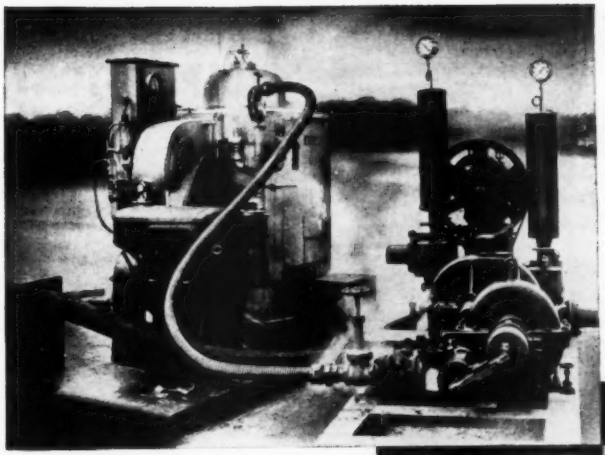

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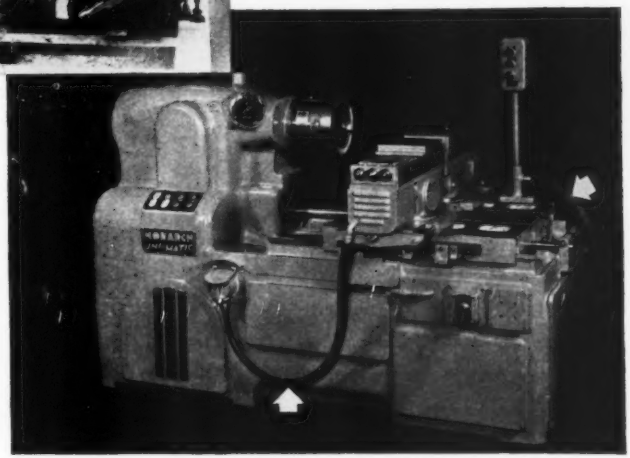

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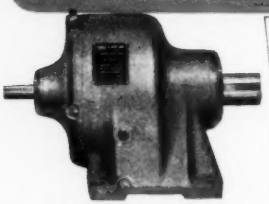

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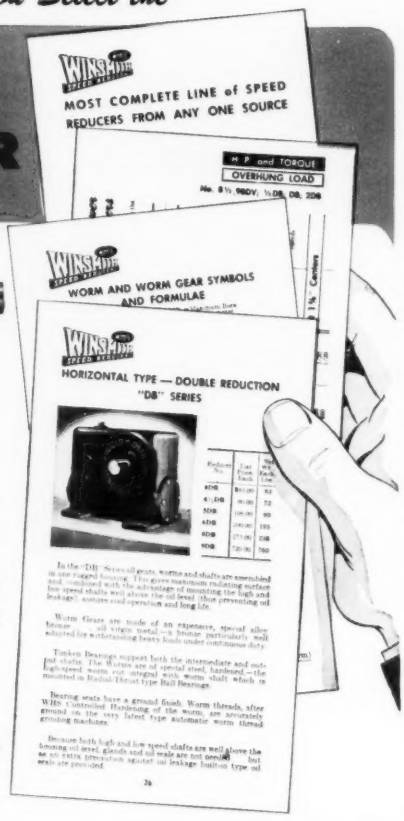
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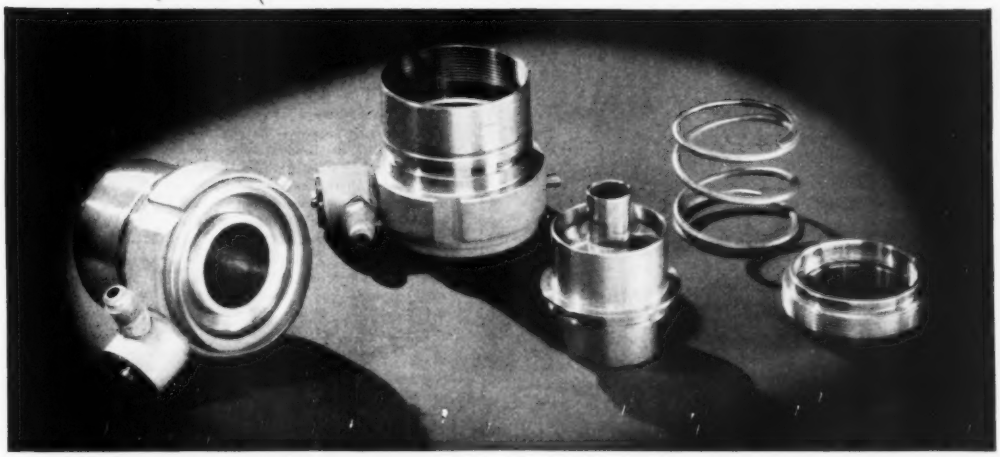

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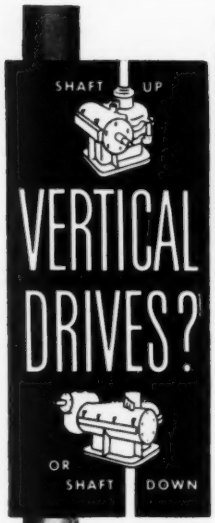

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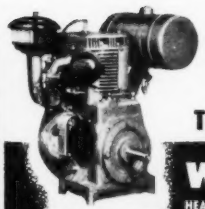

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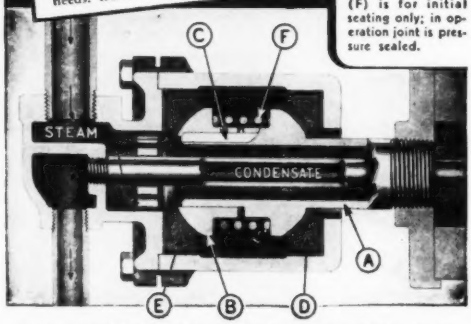

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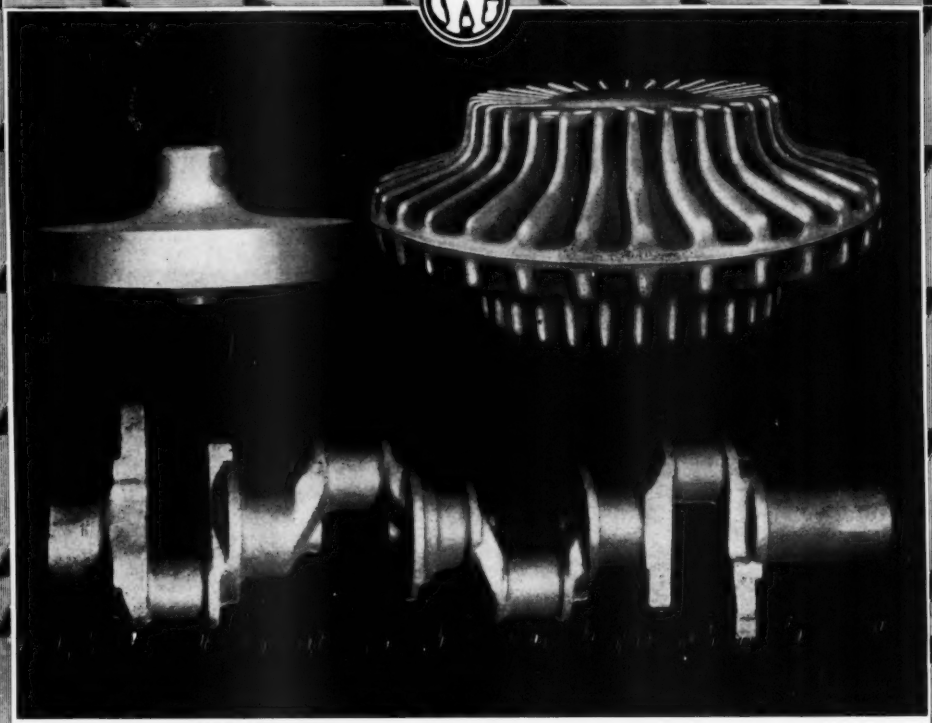

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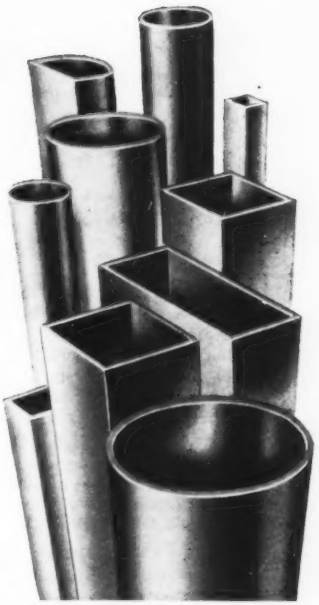

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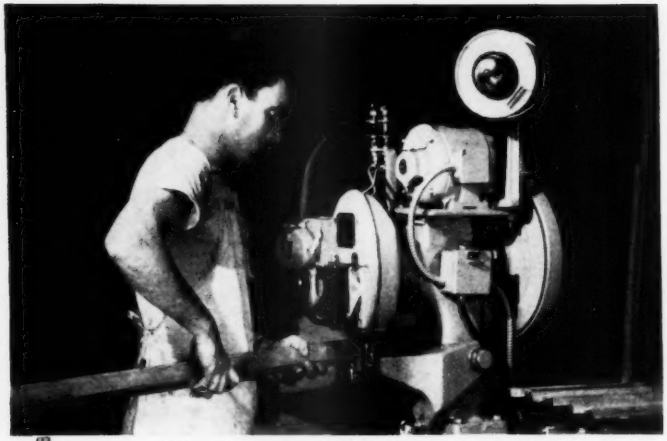
From its own raw materials, J&L manufactures a full line of carbon steel products, as well as certain products in OTISCOLOY *and* JALLOY *(hi-tensile steels).*

PRINCIPAL PRODUCTS: HOT ROLLED AND COLD FINISHED BARS AND SHAPES • STRUCTURAL SHAPES • HOT AND COLD ROLLED STRIP AND SHEETS • TUBULAR, WIRE AND TIN MILL PRODUCTS • "PRECISIONBILT" WIRE ROPE • COAL CHEMICALS



Rubber feet are wire-stitched to aluminum ladder legs neatly and securely with an Acme-Morrison Metal Stitcher.

Cut Assembly Costs with ACME-MORRISON METAL STITCHER

Read how a California manufacturer did it

Fastening rubber feet to aluminum ladder legs is a simple operation as done by an Acme-Morrison Metal Stitcher in the Burbank, California, plant of Bardwell & McAlister, Inc. In a single operation, the stitch is formed, driven through 1/4 inch of rubber and 3/32 inch of aluminum, and clinched neatly and securely.

"We have realized a saving," the firm says, "of approximately two minutes' assembly labor per ladder over the old method of bolting; a saving of the cost of four screws, nuts and washers; and an increase in the strength and rigidity of the joint."

If you fasten metal to metal, or nonmetallic materials to metal, you should know about the savings possible when you use versatile wire stitches to replace rivets, screws, nails, bolts, and spot welding—stitches that require no pre-punching.

Why not find out what an Acme-Morrison Metal Stitcher can do for you? Mail the coupon today.

CROSS-SECTION VIEWS OF STITCHES

Aluminum, leather and copper stitched together
Aluminum, plywood and brass stitched together
Textile stitched to aluminum

STITCHING WIRE DIVISION

ACME STEEL COMPANY

NEW YORK 17 ATLANTA CHICAGO 8 LOS ANGELES 11

ACME STEEL COMPANY, Dept. PE-49
2840 Archer Avenue, Chicago 8, Illinois

Send details about the Metal Stitcher.

Name _____

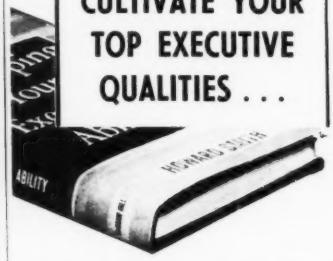
Company _____

Address _____

City _____ Zone _____ State _____

What makes one man worth $40,000 — another only $4,000? . . . this book tells . . .

HOW TO CULTIVATE YOUR TOP EXECUTIVE QUALITIES . . .



—and win success faster in the upper brackets

TOP EXECUTIVES aren't born. They're made. Self-made mostly. Though they rise along different routes, the steps to their success are similar. They follow a definite course of action . . . and arrive at the top **as planned.** Now, here is a practical, inspiring book which brings you this amazing success formula. It outlines a specific, detailed plan for cultivating the qualities which mark the top-flight business leader today—illuminating each point with intimate, on-the-job studies of currently outstanding executives.

DEVELOPING YOUR EXECUTIVE ABILITY

By **Howard Smith,** Personnel Consultant, Noted Lecturer, and Instructor with Dale Carnegie Institute. **225 pages 5½ x 8, $3.00.**

This book provides a blueprint that shows how you can win executive success. Showing that executive genius is not a quality one is born with, but the result of concentrated effort along the right lines, the book tells how to direct the same efforts and thinking which you already expend daily toward the definite goal of improving your executive ability. Packed with helpful pointers it tells how the up-and-coming executive can make the most of his capabilities, grow in executive stature, and rapidly qualify for the upper bracket responsibilities and rewards.

Some facts this book gives you:

- how to plan advancement
- the secret of executive personality
- 3 best methods for improving personality
- 11 ways to put over your personality
- 24 guideposts to productive thinking
- 11 aids for making decisions
- 11 steps for handling worries
- how to budget time most efficiently
- 12 tested techniques for giving instructions
- how to talk to groups effectively
- how to handle responsibility
- how to give yourself publicity

10 DAYS' FREE EXAMINATION

McGraw-Hill Book Co., 330 W. 42 St., N.Y.C. 18
Send me Smith's **Developing Your Executive Ability** for 10 days' examination on approval. In 10 days I will send $3.00, plus few cents postage, or return book postpaid. (Postage paid on cash orders.)

Name .....
Address .....
City and State .....
Company .....
Position FPE-4-49

($3.50 in Canada; order from McGraw-Hill Co. of Canada Ltd., 12 Richmond St. E., Toronto 1).

Resistors Illustrated Are Grade 1, Class I, Characteristic "F"

OHMITE JAN TYPE WIRE-WOUND RESISTORS

MEET REQUIREMENTS OF JOINT ARMY-NAVY SPECIFICATION JAN-R-26

STYLES AND SIZES

TAB-TERMINAL TYPE

Style	Overall Length	Diameter	*Watts
RW-30	1"	19/32"	5
RW-31	1½"	19/32"	10
RW-32	2"	19/32"	12
RW-33	3"	19/32"	15
RW-34	5"	19/32"	20
RW-35	4"	29/32"	30
RW-36	6"	1-5/16"	60
RW-37	6"	1-5/16"	75
RW-38	8"	1-5/16"	110
RW-39	12"	1-5/16"	165

TAB-TERMINAL TYPE with terminal hole to clear No. 6 screw

Style	Overall Length	Diameter	*Watts
RW-40	3"	29/32"	25
RW-41	4"	29/32"	32
RW-42	6"	1-5/16"	49
RW-43	8"	1-5/16"	74
RW-44	8"	1-5/16"	100
RW-45	12"	1-5/16"	150

FERRULE-TERMINAL TYPE

Style	Overall Length	Diameter	*Watts
RW-10	11-7/16"	1-5/16"	140
RW-11	9-5/8"	1-5/16"	115
RW-12	7-7/16"	1-5/16"	86
RW-13	5-1/8"	1-1/16"	58
RW-14	4-7/16"	1-1/16"	48
RW-15	3-15/16"	3/4"	33
RW-16	3-3/8"	3/4"	24

*Watts free air, All Characteristic "F"

To qualify for approval under Joint Army-Navy characteristics, resistors are required to withstand in excess of nine cycles of immersion in saltwater baths of 100°C and 0°C; to withstand a severe vibration test for five hours; and, in addition, are subjected to all other tests as specified in JAN-R-26. Ohmite Resistors designed for JAN-R-26 are specially vitreous enameled and have a textured gray finish. Available in the types and sizes listed.

Write on Letterhead for Bulletin No. 139

OHMITE MFG. COMPANY

4920 Flournoy St., Chicago 44, Ill.

Be Right with...

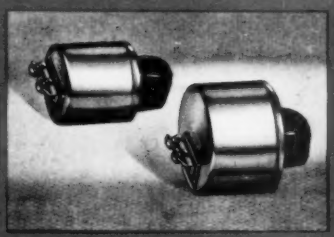
OHMITE

RHEOSTATS · RESISTORS · TAP SWITCHES

Ohmite Rheostats are available in ten sizes from 25 to 1000 watts.

OHMITE RHEOSTATS

MEET REQUIREMENTS OF JOINT ARMY-NAVY SPECIFICATION JAN-R-22



Models H (enclosed) and J (enclosed)
Also AN 3155 (AN-R-14a)

TYPE	OHMITE MODEL	WATT RATING
RP10	H	25
RP11	H enclosed	12.5
RP15	J	50
RP16	J enclosed	25
RP20	G	75
RP25	K	100
RP30	L	150
RP35	P	225
RP40	M	300
RP45	R	500
RP50	T	750
RP55	U	1000

OHMITE RHEOSTATS MEET THESE RIGID TESTS:

- ★ 5-Hour Vibration Test
- ★ 100-Hour Salt-Spray Corrosion Test
- ★ 150-Hour 95% Humidity Electrolysis Test

and other tests as prescribed in Specification JAN-R-22.

By meeting these severe Joint Army-Navy requirements, Ohmite Rheostats have proved what industry has long accepted as true—that they can be depended upon for unfailing performance under the toughest operating conditions. All-ceramic construction . . . a smoothly gliding metal-graphite brush . . . uniform windings locked in place by vitreous enamel . . . insure close control throughout years of trouble-free service. It will pay you to standardize on Ohmite Rheostats for your product.

Be Right with

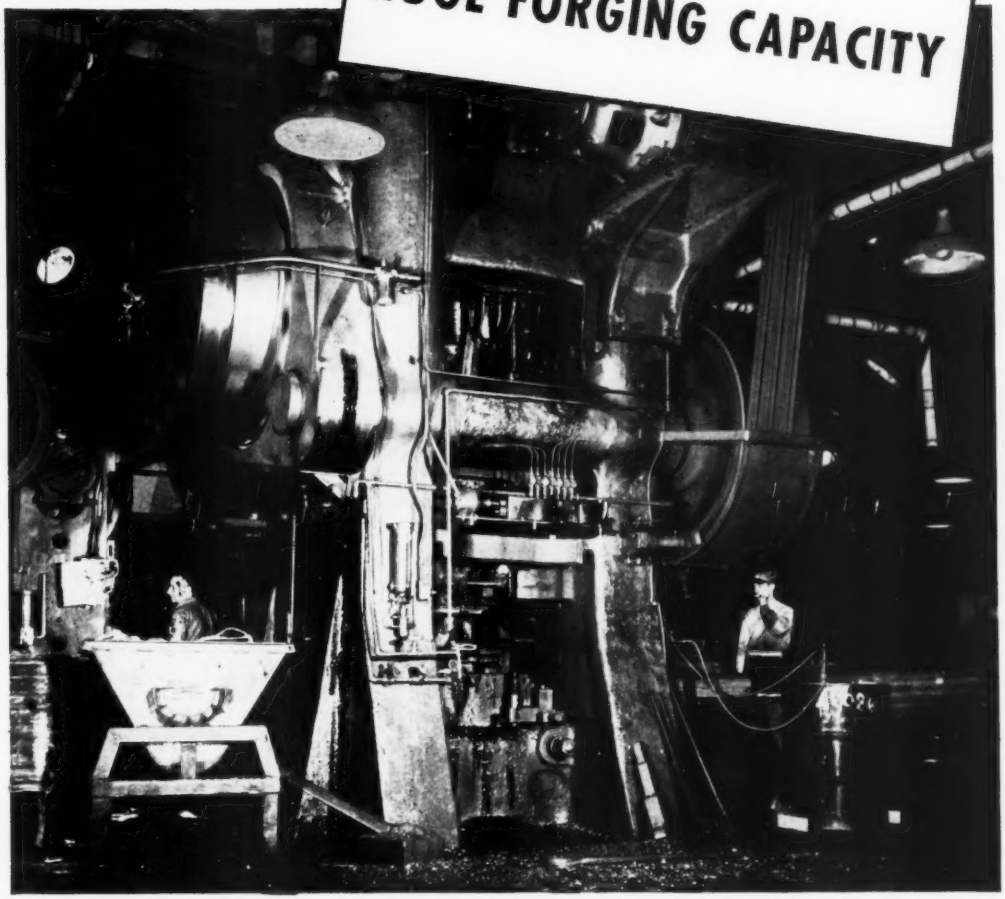
OHMITE

RHEOSTATS · RESISTORS · TAP SWITCHES

See Next Page

for your forging needs—

WILLYS-OVERLAND HAS HUGE FORGING CAPACITY



This 1500-ton hot forging press is among the huge battery of modern equipment in The Willys-Overland Forge.

The Willys-Overland Forge has capacity to produce *80 million pounds* of quality forgings a year . . . ample for your forging needs and the demands of many new customers.

Before placing your next order for forgings, check with The Willys-Overland Forge. You may realize substantial savings in better forgings more adaptable to your specific requirements.

Send for full information on one of America's great forges

DROP FORGINGS

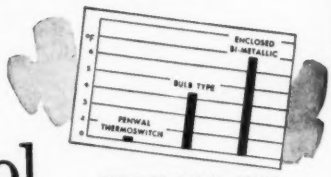
HOT PRESS FORGINGS

UPSET FORGINGS

THE WILLYS-OVERLAND FORGE

WILLYS-OVERLAND MOTORS • TOLEDO 1, OHIO

$7.50 Thermostat Replaces $250 Control Instrument ...and Eliminates Maintenance Costs!



BUILT TO STAND ABUSE
Chart shows the change in the set point of a Thermoswitch* Control in comparison to two other types of thermostat when subjected to a mechanical shock of 100 G.

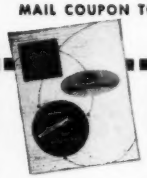
BECAUSE the Fenwal Thermoswitch* is *fast ... accurate ... rugged ... compact ... easily installed* ... and the contacts are *fully enclosed* by the temperature-sensitive shell!

As in this actual solution to a common temperature control problem in the newspaper industry, you too may make amazing savings in heat control.

MAIL COUPON TODAY

Fenwal

THERMOSWITCH*
*Reg. U. S. Pat. Off.
The Precision Thermostat For Temperature Control and Over-and-Under-Heat Detection
SENSITIVE ... *but only to heat*



FREE! Get this bulletin ... see what the Fenwal Thermoswitch* can do for *you.*
Just fill in coupon and mail ... no obligation
FENWAL INCORPORATED, 15 Pleasant St., Ashland, Mass.

Name ..... *Position* .....
Company .....
Street .....
City ..... *Zone* ..... *State* .....

I am chiefly interested in the applications checked:

HEATING
☐ Incubators
☐ Vulcanizing
☐ Pasteurizing

COOLING
☐ Refrigeration
☐ Ventilation
☐ Quick Freezing

PROCESSING
☐ Canning
☐ Cooking
☐ Refining

SAFETY WARNINGS
☐ Engines
☐ Motors
☐ Transformers

HEATING
☐ Limit switches
☐ Oil burners
☐ Hot water tanks

LABORATORY EQUIPMENT
☐ Ovens
☐ Cabinets
☐ Liquid baths

OTHER (Please fill in your special requirements) .....
.....

F-18A

HERE'S A

Parade

YOU WON'T WANT TO MISS...

Everybody loves a parade but here's one that's particularly interesting to YOU because it's packed with "pocket-book" appeal. It's a never-ending parade of products and services designed to help you do *your* job better, quicker and cheaper. You're in the "reviewing stand" for this parade because it comes to you in the advertising pages of every issue of this magazine. Alert manufacturers use these advertising pages to get the *news* about their products and services to *you* ... quickly and effectively. To be well-informed about the latest developments in *your* industry ... and to stay well-informed ... ***read all the ads too.***

PRODUCT ENGINEERING

INSUROK
by RICHARDSON
Dependable names in plastics

BIG ENOUGH--LITTLE ENOUGH

That's the way a friend recently spoke about the size of The Richardson Company.

His reasons are factors you may want to consider in selecting a supplier of plastics materials and services.

Here's how he put it:

BIG ENOUGH to have ALL of the facilities for big runs of (1) Laminated INSUROK sheets, tubes and rods, (2) punched parts, (3) fabricated parts and (4) Molded INSUROK products (molded of Durez, Plaskon, Melamine, Bakelite, etc.)

LITTLE ENOUGH to give personal and individual attention to EVERY customer and his problem.

Our size is just one of many factors that work in your favor when you turn to Richardson for plastics. Other important benefits are ready to go to work for you . . . such as experience, seasoned laboratory and production talent, competent production skills and a genuine interest in helping you improve your product and control production costs.

Why not discover for yourself what Richardson offers in the way of plastics materials and services?

INSUROK is a registered trade-mark of The Richardson Company

The RICHARDSON COMPANY
GENERAL OFFICES: LOCKLAND, OHIO FOUNDED IN 1858
Sales Headquarters: MELROSE PARK, ILLINOIS

CLEVELAND · DETROIT · INDIANAPOLIS · MILWAUKEE · NEW BRUNSWICK, (N. J.) · NEW YORK · PHILADELPHIA · ROCHESTER · ST. LOUIS

"Everybody talks about the weather, but nobody does anything about it!"
(Attributed to Mark Twain)

Except Chace!

CHACE THERMOSTATIC BIMETAL

Selected for Ohio Thermometer

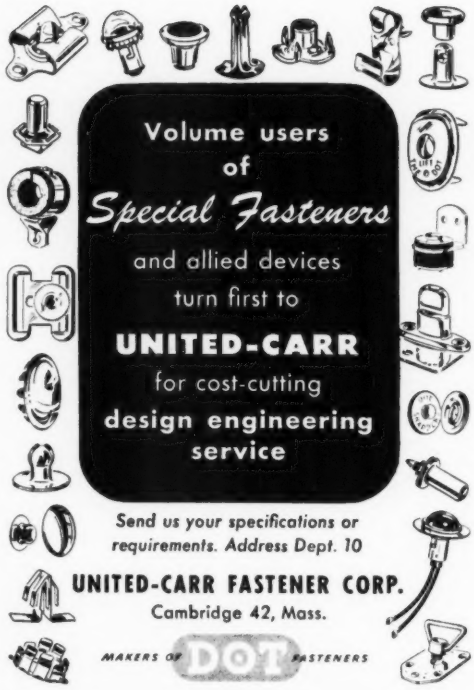
No. 26 — Product of the
OHIO THERMOMETER COMPANY
Springfield, Ohio

A coil of Chace Thermostatic Bimetal in the Ohio Advertising Thermometer helps keep advertisements before the public because, when "Everybody talks about the weather," eyes travel at once to the nearest thermometer.

The Ohio Thermometer uses Chace No. 6650 Thermostatic Bimetal for the thermal element in the form of a spiral coil—one end of which is attached to the indicator shaft, the other end fixed. Change of temperature rotates the pointer to the correct temperature value. The markings on the dial have been carefully graduated to conform to the exact characteristics of the bimetal coil based on actual test, thereby giving accurate temperature indications, throughout its range from −30 to 120°F.

Chace Thermostatic Bimetal is available in strips or finished pieces for various desired applications. For aid in designing the actuating element for temperature responsive devices, consult or write our engineering department.

W. M. CHACE CO.
Manufacturers of Thermostatic Bimetals
1607 BEARD AVE. • DETROIT 9, MICH.



Volume users of *Special Fasteners* and allied devices turn first to **UNITED-CARR** for cost-cutting **design engineering service**

Send us your specifications or requirements. Address Dept. 10

UNITED-CARR FASTENER CORP.
Cambridge 42, Mass.

MAKERS OF DOT FASTENERS

WILLIAMS

DROP-FORGINGS

ANY SHAPE • ANY MATERIAL • COMPLETE FACILITIES

Write for Free Forging Data Folder . . . Helpful, Informative
J. H. WILLIAMS & CO., "The Drop-Forging People" BUFFALO 7, N.Y.

The very best facilities for

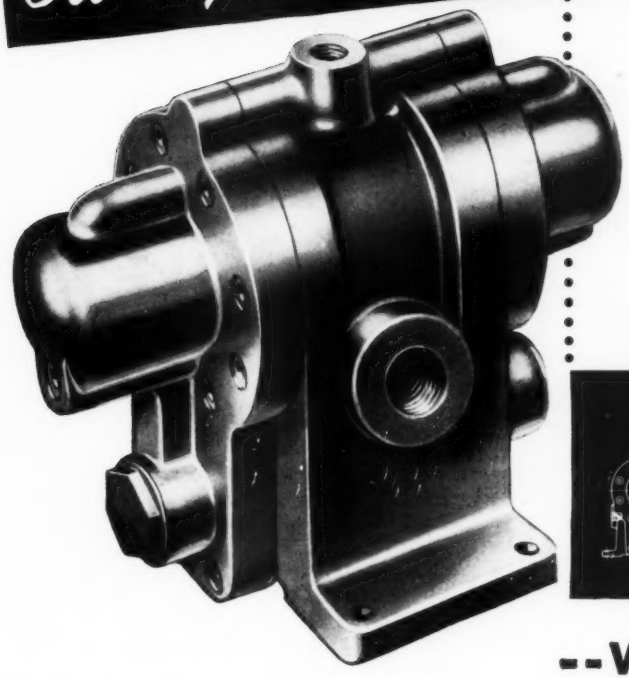
STAMPINGS

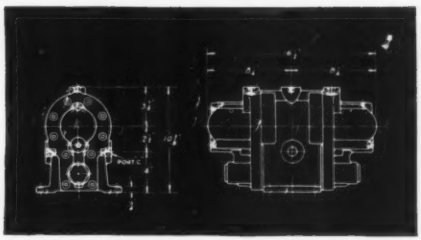
In Small Lots

DAYTON ROGERS
Manufacturing Company
Minneapolis (7), Minn.

A RACINE

Oil Hydraulic Pressure Booster





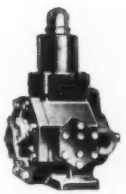
--WILL INCREASE OIL PRESSURES AS MUCH AS 7 to 1

The Racine Hydraulic Pressure Booster is a simple, compact, self-contained pumping unit. It is adaptable to existing or new circuits, using either constant or variable volume pumps. Its use provides high and low pressure for your hydraulic circuit. Horsepower requirements remain constant because as pressure increases, volume decreases.

RACINE HYDRAULIC BOOSTERS reduce initial investment because they eliminate the need of high pressure pumping and extra capacity power units. Compact leak-proof construction. No gears to wear out, no external working parts, no special mounting or foundation required. Standard units are available in various ratios to produce pressures as high as 5000 lbs. p.s.i. Write for complete descriptive circular. Address RACINE TOOL & MACHINE CO., 1772 State St., Racine, Wisconsin.

RACINE

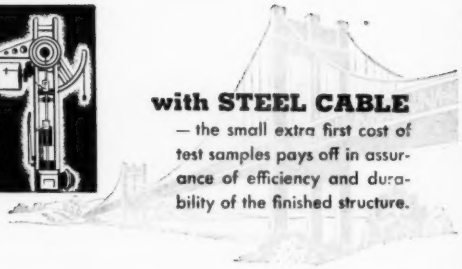
Standard for Quality and Precision



RACINE
Oil Hydraulic
PUMPS AND VALVES

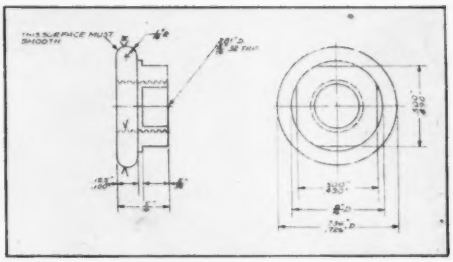
Investigate RACINE'S Variable Volume Hydraulic Pump line. Ideal for use in automatic precision type machine control where low and high pressures are required for either slow or fast operations. 50 to 1000 lbs. oil pressure p.s.i. at 0 to 30 g.p.m.

Racine's Oil Hydraulic Valve line is available in a wide range of styles with either manual, electrical or mechanical controls. Sizes ⅜" to 1½" I.P.S. Ask for complete RACINE HYDRAULIC PUMP CATALOG No. P-10-C.



with STEEL CABLE

— the small extra first cost of test samples pays off in assurance of efficiency and durability of the finished structure.



with TRACING CLOTH . . .

— the small extra first cost of Arkwright Tracing Cloth, over that of tracing paper, repays many times over in the efficiency and durability of valuable drawings.

Lines drawn on Arkwright Tracing Cloth stand out with unusual clarity — a clarity that is permanent because Arkwright does not become opaque or brittle with age. Special mechanical processing, plus sturdy uniform threads expertly bonded, protect your investment through years of service. Perishable tracing paper cannot safely promise this.

Arkwright Tracing Cloths are preferred by foresighted drafting departments *for every drawing worth keeping for future use.* Send for generous samples. Sold by leading drawing material dealers everywhere. Arkwright Finishing Company, Providence, R. I.

The Big Six Reasons Why Arkwright Tracing Cloths Excel

1. Erasures re-ink without feathering.
2. Prints are always sharp and clean.
3. Tracings never discolor or go brittle.
4. No surface oils, soaps or waxes to dry out.
5. No pinholes or thick threads.
6. Mechanical processing creates permanent transparency.

ARKWRIGHT

TRACING CLOTHS

AMERICA'S STANDARD FOR OVER 25 YEARS

Quantity
PRODUCTION
of
GREY IRON CASTINGS

ONE OF THE NATION'S LARGEST AND MOST MODERN PRODUCTION FOUNDRIES

ESTABLISHED 1866

THE WHELAND COMPANY

FOUNDRY DIVISION

MAIN OFFICE AND MANUFACTURING PLANTS
CHATTANOOGA 2, TENNESSEE

FORGINGS and STAMPINGS

DIXISTEEL forgings and stampings are made of carefully analyzed steel produced in our own open hearth furnaces. They are of highest quality and strength.

Send us your prints or specifications for forged or stamped parts, and we will be pleased to submit our estimate for production.

ATLANTIC STEEL COMPANY

P. O. BOX 1714 — DIXISTEEL — ATLANTA 1, GEORGIA

Capillary Tubing

ALL KINDS
ALL SHAPES

ROEHR PRODUCTS CO.
131 EAST 19TH STREET
NEW YORK CITY

For every hand a multiple print of the master plan

The miracle of modern mass production and construction could never have happened had master plans and drawings been passed from hand to hand. Only their creation on superior original materials—and their multiplication by prints on sensitized paper and cloth—has made possible the progress, speed, and accuracy we now enjoy.

Since 1895, POST has had a vital and leading part in this progress through the furnishing of those original materials and the sensitizing of papers and cloths for all types of machines and methods of reproducing plans and drawings. POST is in its 54th year of "better" service and supply to management . . . engineers . . . architects . . . draftsmen . . . who must have the finest.

Write for your SELECTED SAMPLES *Folder of the 5 top* POST *Tracing Papers and mediums—designed to fill any requirement or budget. It will be helpful if you tell us any particular type of paper you prefer. Write care of P. O. Box 1091, Chicago 90, Illinois.*

THE FREDERICK POST COMPANY

3650 NORTH AVONDALE AVENUE · CHICAGO 18, ILLINOIS · · Detroit · Chicago · Houston · Los Angeles · Milwaukee

Distributors in all Principal Cities

FOR EVERY PLAN YOU MAKE — — — THERE'S A PAPER BY POST

One of a series of *messages to help you increase your understanding of business paper advertising, and its effect on your job.*

What's so glamorous about advertising?

THERE IS A curious belief in some quarters that advertising lives in a glamorous and almost occult world of its own, quite insulated against the cold science of the production line.

That, of course, is pure Hollywood.

Advertising today (in the *business* press, at least) is about as glamorous as a drop forge, and twice as efficient. It can become just as important to your profit-and-loss picture as plant maintenance, safety engineering, production techniques or cost-accounting. Maybe even a little more so.

Because the biggest plant capacity, and the best production know-how, can't create a single dollar of profit – *not until something is sold.* And selling, in our economy, is a mass production job!

Advertising simply provides the necessary machinery. It is the application of assembly line methods to the *manufacture of a sale.* For sales don't just "happen." Like any other commodity, they require a series of processing operations. Usually, it takes five:

1. **Seeking out prospects**
2. **Arousing their interest**
3. **Creating a preference for your product**
4. **Making a specific proposal**
5. **Closing the order**

By *mechanizing* the first three of these operations, advertising enables your salesmen to concentrate on the two jobs which they alone can do, and do best. And nowhere does the machinery of advertising work more efficiently than in the business press, where it reaches the greatest number of interested prospects, at the lowest possible cost.

Maybe – to the man who appreciates machinery – advertising is a pretty glamorous business, at that!

PRODUCT ENGINEERING

is a member of The Associated Business Papers, who have just published a book entitled, "Copy that Clicks with readers." Next time you see your advertising manager, ask him to show it to you. And if you'd like a copy of your own, we'll be glad to mail you one.

NOW . . . there's a big change in this picture

And you see it in quicker P-K Self-tapping Screw deliveries

REMEMBER THIS PICTURE? We used it in an August, 1946 advertisement to illustrate the serious shortage of raw materials, a main reason why deliveries of P-K Self-tapping Screws were so slow.

Now, there's a big change. Supplies of steel wire are almost normal. Backlogs have been worked down. Stocks have been built up. As a result, on most sizes of screws, in all types, prompt deliveries are again being made.

Today, there is no longer any reason why any manufacturer need accept a substitute when he wants P-K Self-tapping Screws. Parker-Kalon Corporation, 200 Varick Street, New York 14, N. Y.

GOOD NEWS FOR ALL USERS OF PARKER-KALON SELF-TAPPING SCREWS

YOU'RE *O·K* WITH *P-K* ... THESE *EXTRAS* PAY

- ORIGINATORS OF SELF-TAPPING SCREWS
- ONLY COMPLETE LINE
- 35 YEARS' APPLICATION EXPERIENCE
- EXPERT ASSEMBLY ENGINEERING
- UNSURPASSED QUALITY CONTROL LABORATORY
- LARGEST PRODUCTION FACILITIES
- TOP-RATED DISTRIBUTORS EVERYWHERE

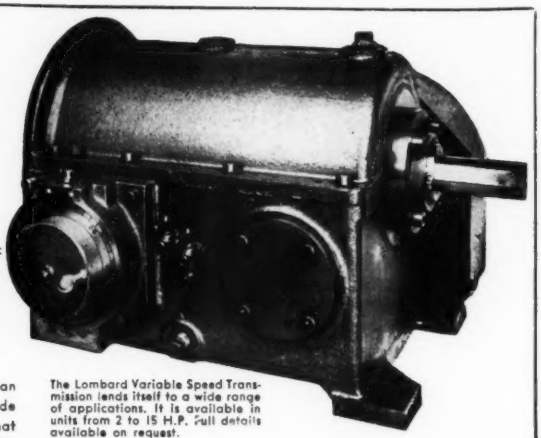
AVAILABLE THROUGH P-K ACCREDITED DISTRIBUTORS

PARKER-KALON *Original* **SELF-TAPPING SCREWS**

FOR EVERY METAL AND PLASTIC ASSEMBLY

OTHER PARKER-KALON PRODUCTS: Cold-Forged Socket Screws, Wing Nuts, Thumb Screws Hardened Screwnails and Masonry Nails · Shur-Grip File and Solder Iron Handles Metal Punches · Damper Regulators and Accessories

THE NEW LOMBARD TRANSMISSION



The Lombard Variable Speed Transmission lends itself to a wide range of applications. It is available in units from 2 to 15 H.P. Full details available on request.

. . . for applications requiring infinite variation in speeds

By incorporating the Lombard Variable Speed Reducer as an integral part of equipment, it is possible to provide a wide range of easily controlled useful speeds. Design is such that a speed range of greater than 20 to 1 can be obtained with a minimum speed approximating zero.

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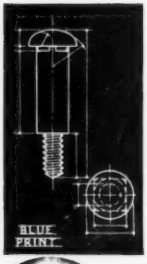

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Types for most Operating Purposes

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Bonderizing for aluminum is effective, economical, quick, and simple. On sheets or castings of this metal and its alloys, the Bonderite crystals form a tight nonmetallic phosphate coating which becomes part of the metal itself. Paint finish, applied over Bonderizing, is there to stay, and retains its fine appearance through years of hard service.

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LINDE Synthetic Sapphire!

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LINDE synthetic sapphire is characterized by a low coefficient of friction, high melting point and hardness, and unusual chemical resistance. Applied in many diverse problems, it has paved the way for a longer trouble-free life, for both small and large parts.

Economical to fabricate, valuable uses for this material are constantly being developed. A few of the many applications to new equipment include: precision balls, sleeve bearings, rods, and orifices.

Call or write any LINDE office for detailed information on your specific design problems.

ELECTRICAL LOSS

CORROSION

WEAR

Chemical Composition	Al_2O_3
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Melting Point	2030°C.
Dielectric Constant	7.5-10
Coefficient of Friction	0.140
(Steel pivot on sapphire ring)	(0.160 graphite)
Chemical Resistance	Inert to common acids, 30% NaOH at 80°C., and HF at 300°C.

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Unit of Union Carbide and Carbon Corporation

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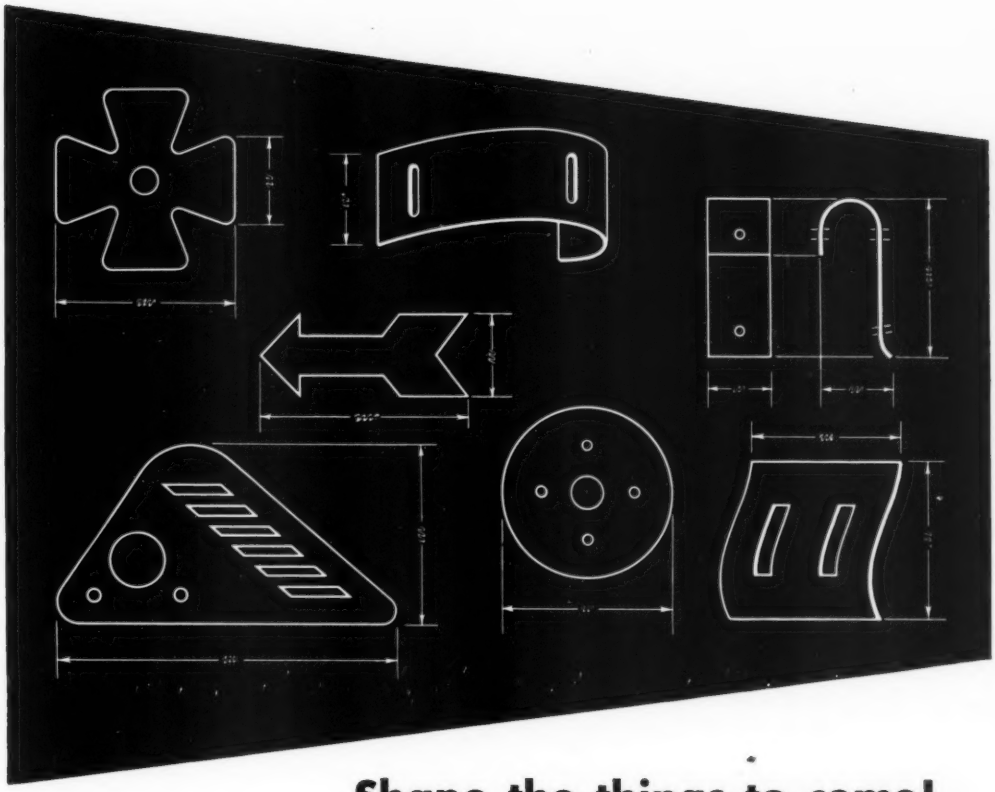
The term "Linde" is a trade-mark of The Linde Air Products Company.

P-13A

Manufacturers use the advertising pages in this magazine to get *news* about their products or services to *you*... quickly and effectively. Their advertisements contain information designed to help you do your job better, quicker, and cheaper, which is just as newsworthy as the editorial columns.

To be well-informed about the latest developments in *your* business, *your* industry...and to stay well-informed... *read all the ads too.*

McGRAW-HILL PUBLICATIONS



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HERE'S a line of basic materials with practically no limit to their versatility. They are the seven different types of Masonite brand hardboards, from Panelwood to the sensational new Leatherwood that has the rich look and feel of fine Spanish leather that has been skillfully worked by master craftsmen.

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Masonite hardboards have proved themselves in nearly every American industry over the past 20 years. They provide quality construction without high cost. They make thousands of things better—thousands of better things are made with them. And designers, builders and manufacturers are still finding new uses for them! See our insert in Sweet's PD File.

MASONITE®

BRAND®

PRODUCTS

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TEMPERED PRESDWOOD
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LEATHERWOOD • TEMPRTILE
PANELWOOD • TEMPERED DUOLUX

"Presdwood" and "Temprtile" are registered trade-marks. "Masonite" signifies that Masonite Corporation is the source of the product.

SAMPLES and LITERATURE!

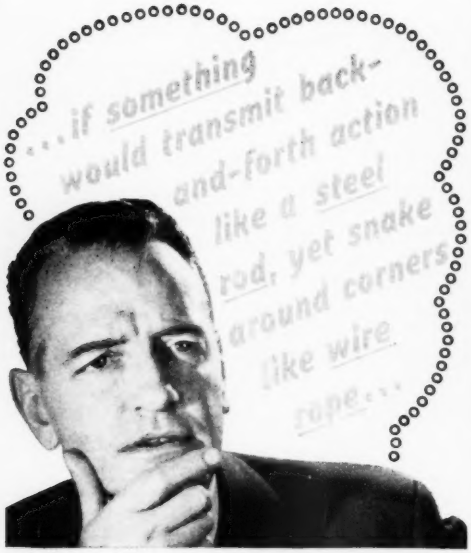
MASONITE CORPORATION
Dept. PE-4, 111 W. Washington Street, Chicago 2, Ill.

Please send me "Product Designers Guide" and samples of Masonite hardboards.

Name _____

Firm and Title _____

Address _____



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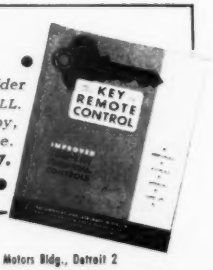
- . . . is precision-made, assuring minimum backlash and long life

This is a descriptive folder about TRU-LAY PUSH-PULL. If you do not have a copy, write our Detroit office. Just ask for **DH-87.**



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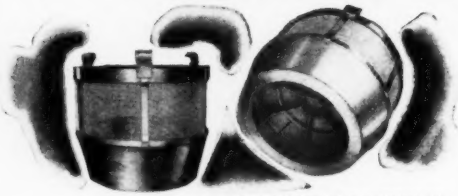

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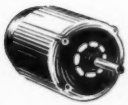
DIE CASTING makes ends meet to lower Production Costs

CASE HISTORIES FROM MT. VERNON FILES

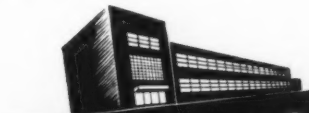


Electric motors have housing problems too! For example, end shields must provide perfect alignment and precision ball bearing mountings for the armature, plus effective air directional ports for motor ventilation. In addition, such components must have strength, to protect the mechanism they cover; must make close, firm fit with main housing.

By means of die casting, an intricate item such as a motor end shield is produced rapidly and economically — the apertures, ribs, lugs, flanges and shapes required being obtained virtually instantly, as the die closes.

And the versatility inherent in die casting affords opportunity to cut production costs still further, by simultaneously casting the mating end shields of a motor housing — as done in this case for The Apex Electrical Manufacturing Company, of Cleveland, Ohio by Mount Vernon.

Whatever your product, remember the cost-cutting possibilities offered by die casting before you next set up a manufacturing procedure — and consult with us. We have shown many manufacturers the way to important savings in time and effort, lower unit costs, increased output, improved products. Case histories are yours for the asking.



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How to reduce APPARATUS PORCELAIN COSTS

IF apparatus porcelain costs have you stymied . . . on products either existing or planned . . . bring your problem to Locke.

HERE, at your disposal, is one of the world's finest and largest Ceramic Research Laboratories, staffed by experts whose porcelain "know-how" is backed by Locke's more than 55 years experience with *all* phases of porcelain design and manufacture.

FREQUENTLY Locke, in combination with your engineering department, can effect major cost reductions in apparatus porcelain by re-designing a piece so that it lends itself to modern low-cost manufacturing techniques.

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CONSULT your local Locke representative, or write direct. Address Department AP.

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Costly hood design

Less costly hood design

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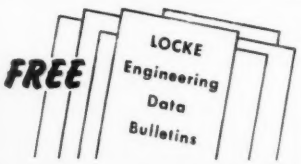

Contain plenty of money-saving hints on the design and manufacture of apparatus porcelain. Write for your free copy—today.

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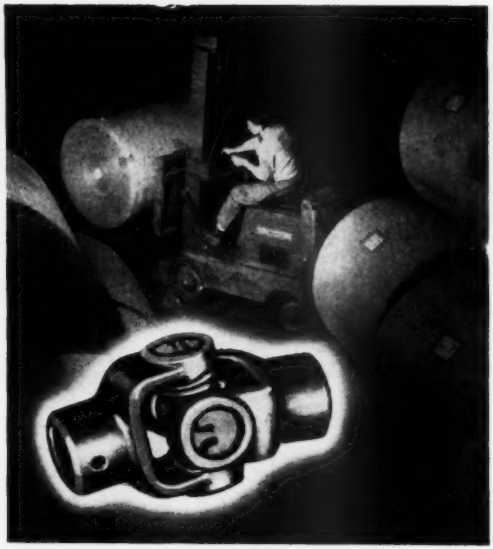

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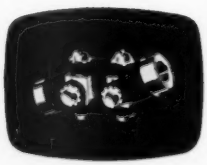

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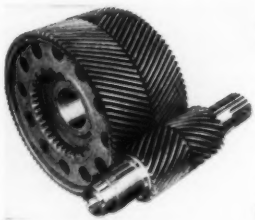

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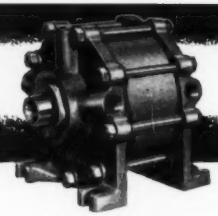
* Fluid Power Improves Production

"LOGAN" AIR CYLINDERS

STANDARD AND HEAVY-DUTY MILL-TYPE



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- More sturdy construction.
- Standard models available with or without cushioning.

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7 STANDARD MOUNTING TYPES

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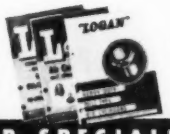
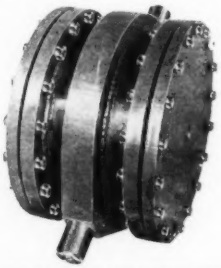


LOGAN STANDARD AIR CYLINDERS

Replace most manual operations . . . eliminate human error.



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For steel mill or aluminum extrusion mill, foundry and heavy-duty service.

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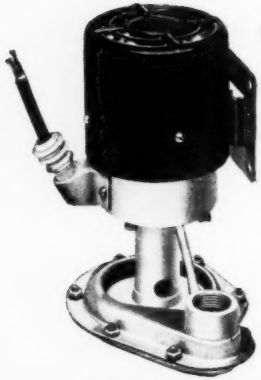

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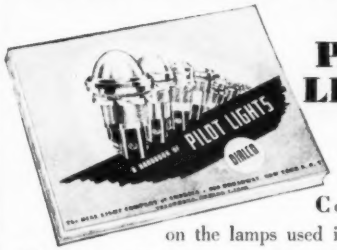

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SLEEVE BEARING DATA

Selecting the Alloy

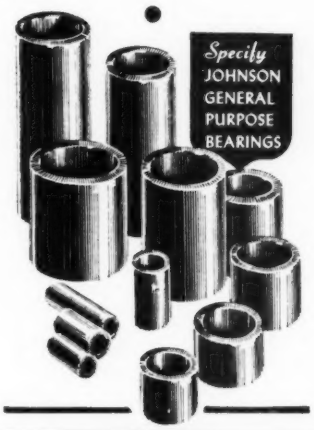
The many and various applications for sleeve-type bearings make necessary the availability of a variety of bearing metals possessing many distinctly different properties. Each particular bearing metal must be best suited for those conditions of service wherein its outstanding characteristics will be of greatest advantage. Accordingly, in the selection of a bearing material it is necessary that the service conditions and the destructive forces on the bearing be analyzed first and the bearing material be then selected for each specific application.

The first step is to accumulate accurate operating data such as speeds and loads . . . whether constant or intermittent . . . method of lubrication; the presence of acid, harmful chemicals, gases, grit or dust; the type of shaft to be used.

All sleeve bearings operate in direct contact with the shaft until the creation of the necessary film of lubricant. Consequently, the following physical properties govern the suitability of a bearing metal: (1) Plasticity; (2) Ability to Resist Wear; (3) Coefficient of Friction; (4) Compressive Strength; (5) Resistance to Pounding; (6) Toughness.

While there are over one hundred bronze bearing alloys from which to make your selection, we have found through experience that the following will meet practically every application.

Johnson Bronze Alloy No	Average Chemical Composition				
	Copper Cu	Tin Sn	Lead Pb	Zinc Zn	Nickel Ni
19	70.0	11.0	19.0	. . .	. . .
25	75.0	5.0	19.0	. . .	1.0
27	80.0	10.0	10.0	. . .	. . .
29	78.0	7.0	15.0	. . .	. . .
51	87.0	10.0	1.0	2.0	. . .
53	88.0	10.0	. . .	2.0	. . .
55	86.0	12.0	. . .	2.0	. . .
66	85.0	5.0	9.0	1.0	. . .
71	85.0	5.0	5.0	5.0	. . .
72	83.0	7.0	7.0	3.0	. . .



Stock Size Bearings

For ordinary service applications and for quick, easy replacement Johnson Bronze maintains a stock bearing service that comprises over 850 individual sizes. This includes inside diameters from ¼" to 4¼"; outside diameters run from ⅜" to 4½"; lengths are available from ¾" to 8". All of these sizes can be quickly altered and any type oil groove, slot or hole can be economically added. Complete stocks are carried in all important industrial centers.

Engineering Service

Johnson Bronze offers manufacturers of all types of equipment a complete engineering and metallurgical service. We can help you determine the exact type of bearing that will give you the greatest amount of service for the longest period of time. We can show you how to design your bearings so that they can be produced in the most economical manner. As we manufacture all types of Sleeve Bearings, we base all of our recommendations on facts free from prejudice. Why not take full advantage of this free service?

Catalogue

Over eighty pages fully illustrated. Lists and describes the most complete stock bearing service in the market. Write for your free copy.

This bearing data sheet is but one of a series. You can get the complete set by writing to—

Johnson Bronze

SLEEVE BEARING HEADQUARTERS

508 S. MILL ST. · NEW CASTLE, PENNA.

contact

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***first for** custom-cut*

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We have manufactured precision gears to customers' specifications for nearly 30 years. Our production equipment comprises modern machine tools and our facilities are ample to meet all demands for the mass production and prompt delivery of such gears.

Our engineers will be glad to work with you on any problems you may have pertaining to gear design. Recommendations as to proper design for *LOWER COSTS*—cheerfully given. Once your specifications are in our files, reorders are filled automatically. *LET US QUOTE ON YOUR REQUIREMENTS NOW!*

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PERKINS MAKES in all materials, metallic & non-metallic:

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We are also exceptionally well equipped to build, to your specifications, such mechanical units as—

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either in experimental or production quantities. Our well-known reputation is your guarantee of satisfaction. Let us quote on your requirements.

SPEED CONTROL

for

Electrical Drives

You probably read this authoritative and helpful feature article in the January issue of PRODUCT ENGINEERING. Concisely written, it surveys performance characteristics and equipment requirements. Charts and drawings graphically illustrate important design factors discussed in its 32 pages.

For those who would like copies of this basic treatise for distribution to their technical staffs, we have a supply on hand.

Reprints in booklet form are available in limited quantities at 25¢ each from Reader Service Department.

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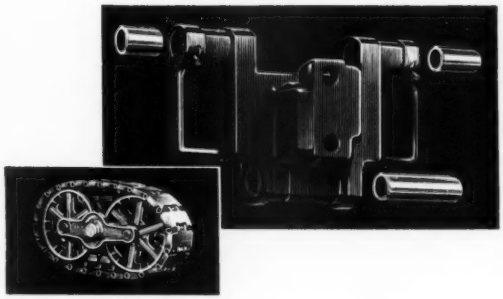
Stocks Carried.

Track Shoes for a Heavyweight



SEE those crawler wheel track shoes on the unit behind the tractor? They carry heavy loads over rock, sand, clay, and gravel — through mud, snow, and water. That means every part has got to be super-tough—particularly the bushings that hinge the shoes together. Imagine the constant twist and strain, pound and jolt — the harsh grinding wear of tiny abrasive earth particles that these bushings must stand.

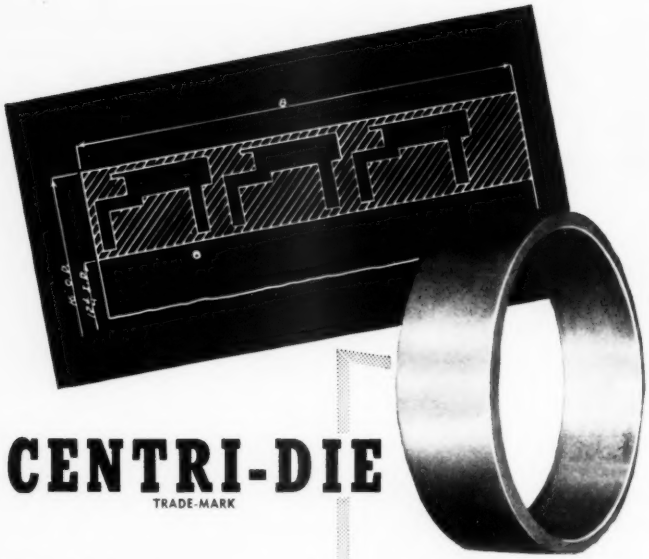
The Trackson Company, makers of these crawler units, brought this problem to Globe Steel Tubes Co. Globe made specific recommendations for a tough, heat-treated alloy steel tubing in a special self-locking lug shape to make these bushings. Result: the Trackson Company simplified production —bettered their product. If you have a design or a production problem—investigate tubing as a possible answer for minimizing machining, lowering cost, reducing weight, improving product performance. Write — Globe Steel Tubes Co., Milwaukee 11, Wis.

Photo — Courtesy of the Trackson Company, Milwaukee

Globe Seamless Stainless Steel Tubes — Gloweld Welded Stainless Steel Tubes — Globe Mechanical Tubes — Globe-iron Seamless High Purity Ingot Iron Tubes — Globe Aircraft Tubes — Pressure Tubes — Carbon and Alloy Steel Tubes — Globe Welding Fittings.

GLOBE

STEEL TUBES



CENTRI-DIE
TRADE-MARK

Illustrated above is a cross section of the metal ring shown in the photograph. Notice how three rings of intricate cross section have been grouped in this one cylinder to conserve metal. By Lebanon's CENTRI-DIE process of centrifugal casting a uniform metal structure is assured throughout each ring as finally machined.

A booklet describing this new casting process and the alloys adaptable to CENTRI-DIE production is yours for the asking.

a NEW casting process which assures greater uniformity of metal structure

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1. Higher quality castings of greater density, resulting in decidedly enhanced physical properties.
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Chances are you will always find in PRODUCT ENGINEERING's "New Catalogs and Bulletins" insert several listings offering literature which will supplement the articles and advertisements which are of greatest interest to you.

So, each month, be sure to check through the "New Catalogs and Bulletins" and send us your requests. Without cost to you, we'll see to it that the manufacturers concerned receive your requests promptly.

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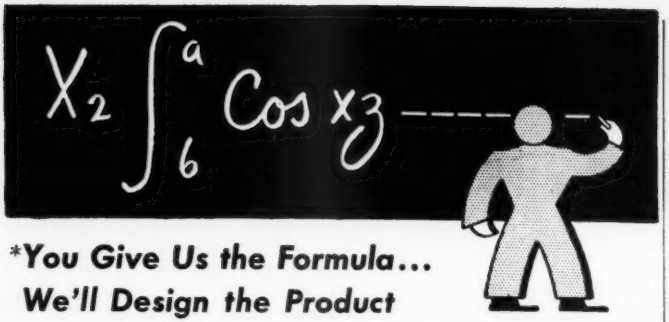

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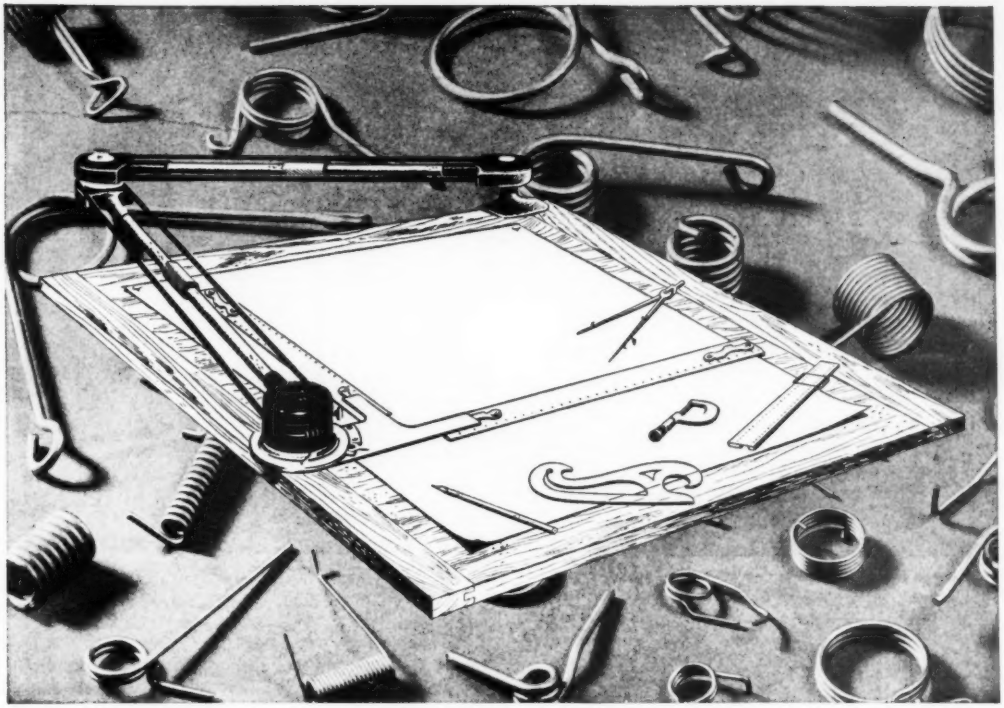

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THE DESIGN of a satisfactory spring involves innumerable factors—load, deflection, size, shape, finish—to mention a few. Having determined these requirements, Wickwire Spencer engineers begin—with brains and blank paper—to establish the proper relationship between these factors and to design a spring that will stand up under the service requirements demanded.

The same exacting care that characterizes the design of springs and wire forms, is equally true as far as manufacturing procedures are concerned. Every coil of wire used in making springs undergoes exhaustive tests before manufacture. Skilled toolmakers set up machines that make springs conform to exacting specifications. And finally, the springs are tested before shipment.

This beginning-to-end-control has saved time, trouble and expense for scores of manufacturers—has won many loyal customers for us. Our engineers are at your service in designing any conceivable type of wire spring or wire form. Why not write us? Also, we would like to send you our free book, "Springs and Formed Wires." It's free—and full of valuable data relating to spring selection and performance. Address your request to Spring Dept., Wickwire Spencer Steel Division of C. F. & I., 2 New Bond St., Worcester 6, Mass.

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A PRODUCT OF THE WICKWIRE SPENCER STEEL DIVISION • THE COLORADO FUEL AND IRON CORPORATION

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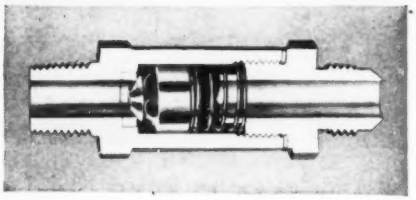

Metal-to-metal seats are best suited for high pressures, extreme temperatures, and corrosive fluids.

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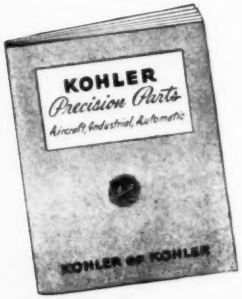

The complete line of Kohler Precision Parts includes check valves for all aircraft, industrial and automotive installations. Leading manufacturers specify Kohler valves for lines using hydraulic fluids, gasolines, lubricating oils, aromatic fluids, air, vacuum, water, acids, chemicals, etc.—and requiring a *pressure regulating valve, pressure relief valve, vacuum breaker, restrictor check, check valves with high or low opening pressures or check valves for special applications.*

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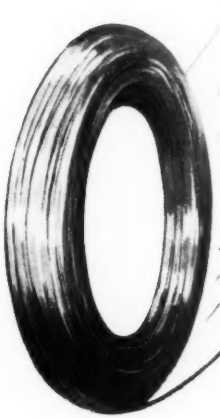

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worth looking back on . . .

Remember the outstanding special editorial reports which appeared in last year's issues of PRODUCT ENGINEERING? The reports on Experimental Stress Analysis . . . Electrical Wiring for Motor-driven Machines . . . Patents and the Engineer . . . Plastics . . . Plain Sleeve Bearings?

They represent the kind of *exceptional* and *exclusive* editorial values which make PRODUCT ENGINEERING the outstanding magazine in its field . . . the magazine 18,000 product-design engineers gladly *pay to read* because they value it, need it, and can find comparable job help nowhere else.

And just in case you missed it, be sure to see this year's first special report . . . Speed Control for Electrical Drives. In the January issue, this 32-page, detailed analysis of one of design engineering's most important subjects is good evidence of the even better editorial job we're out to do this year.

. . . and exciting to look forward to

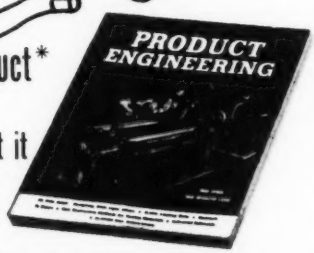
The March issue has another outstanding "first" for PRODUCT ENGINEERING's readers, too. It's the 12-page special report on NEMA Motor Standards . . . the first simple, condensed, practical compilation of these important standards yet published.

And one date you want to be sure and make is with the coming June issue. At a time when every company is concerned with redesigning its products to sell successfully in a buyer's market, this issue will be completely devoted to "Designing for Lower Costs." We are sure no subject could be more timely, or of wider interest to product-design engineers.

And we're sure, too, that no other magazine can cover this subject for the specific benefit of design engineers as well as PRODUCT ENGINEERING. If you want further details on the June issue, ask your PRODUCT ENGINEERING representative for them. It's worth hearing more about!

FIRST with the men who are **FIRST** to specify your product*

*if you make them want it



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CHAPMANIZING is the *fast, modern way* to surface harden free-working steel. In only 1 to 4 hours it will give you an alloy-like case from .002" to .035" deep — a case so tough and ductile it will not chip or check. Because the surface comes out silver-clean, minimum finish grinding is required.

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We'll be glad to send you a copy of the bulletin describing these two Chapman processes for low carbon and stainless steels. Just write for "Chapman Processes."

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The Chapman Valve Mfg. Co.

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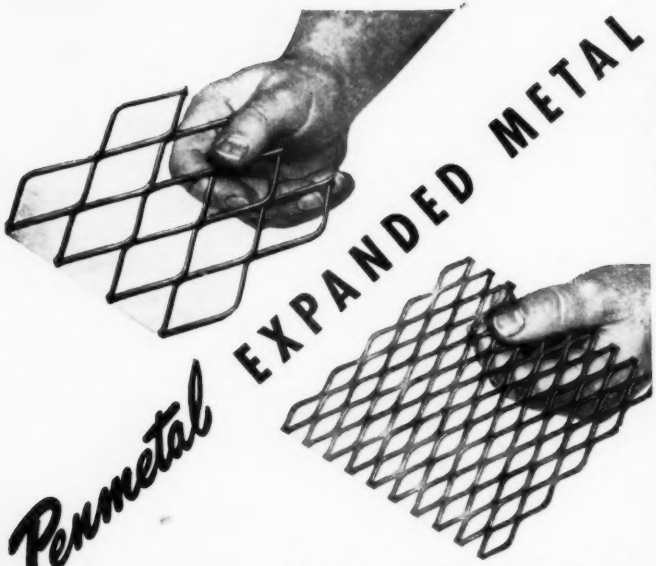

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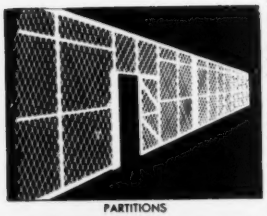
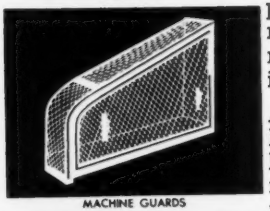


PARTITIONS

Machine guards, grilles, doors, panels, furniture, baskets, display racks, toys—literally hundreds of new uses are constantly developing.



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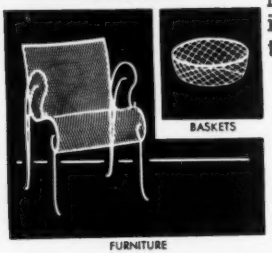

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Our EXPANDED METAL booklet shows many present uses, and may suggest profitable ones for you. May we mail a copy to you?

80th PENMETAL YEAR

PENN METAL COMPANY, INC.

General Sales Offices: 205 East 42nd Street, New York 17, N. Y.

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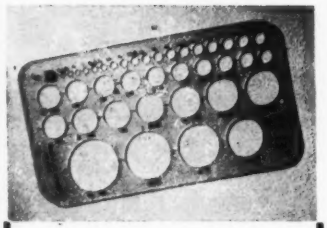
Factory: Parkersburg, W. Va.



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Thirty-nine circles grouped in progressive sizes from 1/16" to 1-3/8". Increments in 64ths to 11/32"—32nds to 3/4"—16ths to 1"—8ths to 1-3/8". The corners provide radii of 1-1/16", 1-3/16", 1-5/16" and 1-7/16" diameters.

The No 40 Circle Template is made of .030, matte finish, super quality cellulose nitrate sheet. Cutouts are precision milled with allowance for pencil point. Each circle size is clearly marked. All have center lines. Actual size is 4" x 7-1/4".

The Biggest Dollars Worth of Template you can buy!

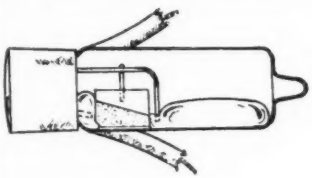
At your local dealer
Catalog No. 49 available on request

RAPIDESIGN, INC.

P. O. Box 592, Glendale, Calif.

POWREX MERCURY SWITCHES

Engineered for Durability



Long life and ease of operation make POWREX switches ideal for designed-in service.

Complete range of designs and sizes up to 30 amperes.

Available from Stock

MAIL THIS FORM TODAY!

POWREX SWITCH CO.
34 Pleasant St., Watertown 72, Mass.

Please send me without obligation your latest Bulletin M-10.

Name .....

Address .....

City ..... State .....

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Company .....

ACROSS-THE-LINE TYPE without overload protection

Everywhere relied upon to give positive control of motors; especially suitable for oil burners, refrigerators, motor-driven machinery and lighting loads.

These switches have rugged, durable mechanisms built to perform with the sturdy integrity characteristic of Arrow-H & H Lines. Bakelite arc snuffers increase breaking capacity; kick-off release mechanically starts the switch blades in motion and prevents sticking; extra-heavy blades and contact jaws increase current-carrying capacity. Different styles of mounting are supplied for a wide range of machine-design requirements. Separate switch units are available for installations in switch housings built into motor-driven machinery.

No. 6808 (upper and lower right) is a double-pole switch for single phase motors; No. 7810 (upper and lower left) is 3-pole for 3-phase jobs. 7810 combines greatly increased mechanical life with *small size:* — $4\frac{1}{16}$" high, $2\frac{11}{16}$" wide, $2\frac{15}{16}$" deep over all. The line includes 3-way, 4-pole and 2-speed reversing switches. All have horsepower ratings... Everything you may need in this line will be found in Motor Control Catalog No. 10 — on request.

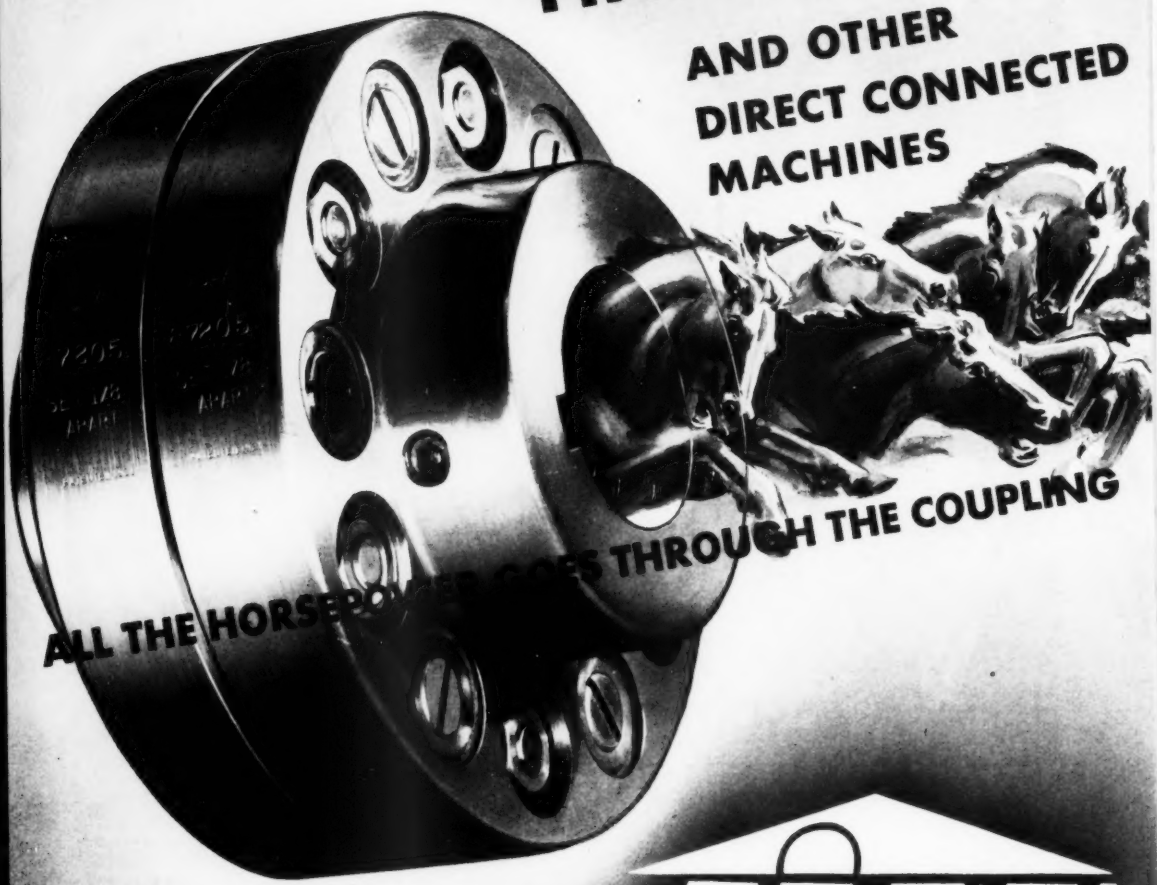
AH

INDUSTRIAL CONTROL DIVISION

THE ARROW-HART & HEGEMAN ELECTRIC COMPANY, HARTFORD, CONN., U. S. A.

and ON AMERICA'S FINEST PUMPS

AND OTHER DIRECT CONNECTED MACHINES



ALL THE HORSEPOWER GOES THROUGH THE COUPLING

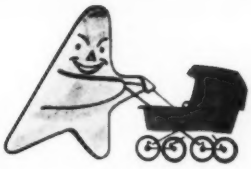
● Design engineers and maintenance men everywhere depend on Ajax Flexible Couplings to protect direct driven machines against unavoidable misalignment. Ajax rubber bushed, self-lubricating bronze bearings and steel drive studs provide positive resilient drive. Wide range of types, sizes and capacities. Write for catalog.

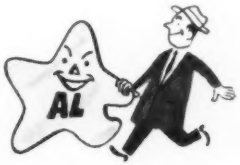
AJAX

FLEXIBLE COUPLINGS

AJAX FLEXIBLE COUPLING CO. INC. • WESTFIELD, NEW YORK

Also manufacturers of vibrating conveyors, screens and packers and Ajax-Shaler shakers

How long 

<u>is</u> a lifetime 

in Stainless Steel?

We call Allegheny Metal "the time-tested stainless steel" because it's the pioneer in America, but time hasn't really tested it yet. Neither we nor anyone else knows how long stainless steel will last. The earliest installations of Allegheny Metal—made more than 20 years ago—are just as bright, strong and resistant as when new. How can you defeat a metal that doesn't wear out and can't wear off? • More important, how and where can you *use* it to advantage, *today?*

W&D 2175

Complete technical and fabricating data—engineering help, too—yours for the asking.

ALLEGHENY LUDLUM STEEL CORPORATION

The Nation's Leading Producer of Stainless Steel in All Forms

AL

Pittsburgh, Penna. . . . Offices in Principal Cities

Allegheny Metal is stocked by all Jos. T. Ryerson & Son, Inc., Warehouses

One of a series *of messages to help you increase your understanding of business paper advertising, and its effect on your job.*

Does your advertising manager rate an invitation to the management table?

IF YOU SHOULD ASK *him*, he'd probably say "yes." And his reasoning might run something like this:

Management's first responsibility is to show a fair profit. This requires a relentless search for continued improvement – in design, in purchasing, in production, research and cost-accounting. Each deserves its place at the management table. Yet none of these activities can actually create a dollar of profit, for the simple reason that you can't *produce* anything at a profit – not unless you can also *sell* it.

And that's what makes the advertising manager's job so important.

His first responsibility is to see that your company's products are made familiar (and desirable) to the greatest number of prospects, at the lowest possible cost. In fulfilling this responsibility, he sets a parallel course with the sales department, although his approach more closely resembles that of the assembly line technician.

For advertising, as he sees it, is simply the application of assembly line techniques to the *manufacture of a sale*. Just consider the five basic steps involved:

1. **Seeking out prospects**
2. **Arousing their interest**
3. **Creating a preference for your product**
4. **Making a specific proposal**
5. **Closing the order**

By *mechanizing* the first three of those steps, advertising increases management's chance to show a profit. It leaves your salesmen free to concentrate on the two jobs which they alone can do, and do best.

And nowhere does this mechanizing process operate more efficiently than in the business press, where it reaches your best prospects at the lowest possible cost.

Perhaps that's why so many smart advertising managers are partial to business paper advertising – and why more of them, incidentally, are getting to sit at the management table!

PRODUCT ENGINEERING

is a member of The Associated Business Papers who have just published a book entitled, "Copy that Clicks with readers." Next time you see your advertising manager, ask him to show it to you. And if you'd like a copy of your own, we'll be glad to mail you one.

Enduring Precision

This spindle bearing is standard equipment on large spindles designed by a world-famous builder of precision grinders. For extreme accuracy, for freedom from vibration, and for enduring precision, only sleeve bearings will do. Where other types of bearing retain their accuracy only for months, Bunting Spindle Bearings endure for years. Where other complex types require a surgical standard of cleanliness and a watchmaker's skill for replacement, the Bunting Sleeve Bearing requires only common-sense and the services of a good mechanic.

The secret of this performance and long life lies in the film type of lubrication. A properly designed and well lubricated sleeve bearing need not acknowledge any superior. No other bearing type possesses its simplicity, its ruggedness, its ability to deliver accurate work for many years. These attributes are possessed by the sleeve bearing.

Bunting engineers are at your service whether your problem is a precision grinder spindle, an aircraft engine, an automobile engine, or something of more or of less exacting requirements. Bunting engineers utilize their extensive experience with bearings of all types in their work of designing Bunting Cast Bronze Sleeve Bearings. The Bunting Brass & Bronze Company, Toledo 9, Ohio. Branches in Principal Cities.

Bunting

BRONZE BEARINGS

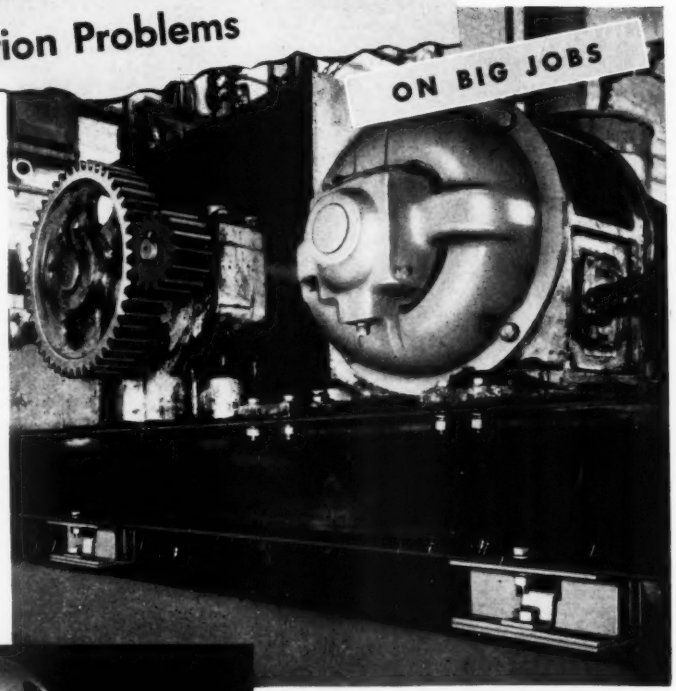
PRECISION BRONZE BARS

BUSHINGS

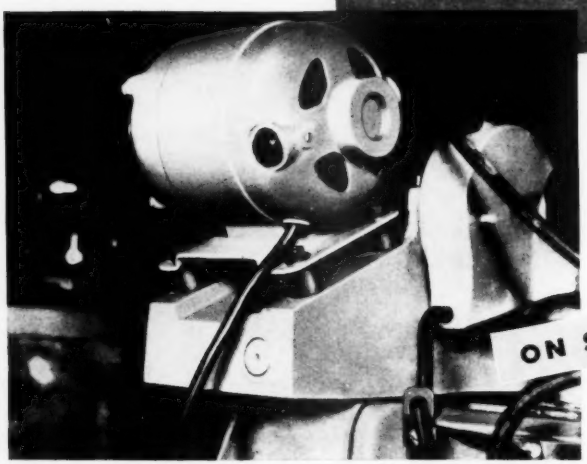
76

An Engineering Service for Designers who have Noise or Vibration Problems

THE engineering staff of United States Rubber Company have been extremely successful in controlling vibration and transmitted noise over a wide range of industrial applications. Maybe you have a problem these engineers could solve ... maybe the answer has already been found by them and can be quickly applied to your product, whether it's big or small, in the blueprint or finished stage.



"I'll cancel your lease," said the building owner to the operators of a storage battery company. Their high pressure pump was transmitting extreme vibration and noise throughout the building. The trouble stopped when United States Rubber Company engineers insulated the rigid steel sub-base (holding both pump and motor—total weight 3,562 lb.) from the building structure, by means of 6 engineered rubber mountings.



Top efficiency in a high speed grinder was not forthcoming until United States Rubber Company engineers insulated the 10,000 rpm motor from the grinder with 4 cylindrical type U. S. engineered rubber mountings. Note how they cushion or float the motor from the grinder itself. Available for engineers, an invaluable book, "Absorbing Vibration, Noise and Impact." United States Rubber Company, 1230 Avenue of the Americas, New York 20, N. Y.

MADE BY

U.S.RUBBER

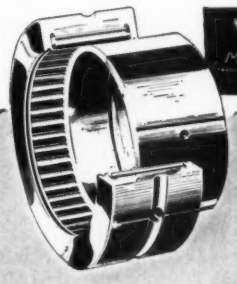
SERVING THROUGH SCIENCE

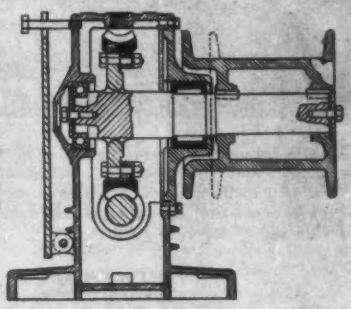
UNITED STATES RUBBER COMPANY

design anti-friction efficiency into out-moded plain bearing applications

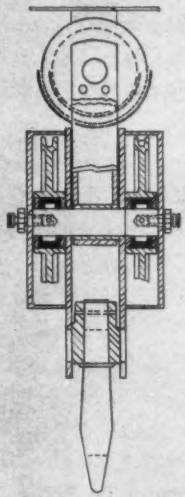
THE *MULTIROL* WAY

When design demands maximum load capacity in limited space . . . plus top anti-friction performance . . . get results with MULTIROL SE Series full type roller bearings. MULTIROL SE Series bearings afford definite performance advantages over friction bound plain bearings. They increase machine efficiency with the kind of smooth precision operation that requires less maintenance for longer machine life — power requirements are less for MULTIROL bearing equipped machinery. SE Series construction is simplified . . . no loose or welded in roller retaining washers . . . lubrication reservoir built in. Smaller radial bearing space with increased load capacity permits more compact and less expensive housing facilities. All add up to improved anti-friction performance. Use with or without inner race in shaft sizes from ⅜" to 9¼". Write for data now!

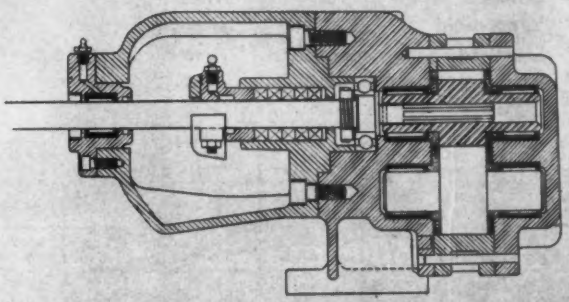




In typical capstan application MULTIROL SE Series maximum capacity bearings fit the small space under the cable drum, yet accept large diameter shaft necessary to carry heavy overhung load.



Use MULTIROL SE Series bearings on sheaves for maximum shaft diameter of pin and minimum housing OD . . . increases load capacity. Lubrication with Alemite fittings need less care than oil bath with plain bearings.



On a rotary gear pump, the heavier load capacity and comparatively small OD of SE Series MULTIROL Bearings permits use of larger shaft that resists deflection. Precision anti-friction requires less power input.

Interested in SE Series MULTIROL bearing advantages? Write today for your copy of Bulletin SE-48. McGill Manufacturing Co., Inc. 201 N. Campbell St., Valparaiso, Indiana

McGILL
TRADE MARK
precision bearings

EXPLOSION-PROOF

DUST-TIGHT • VAPOR-TIGHT • WEATHERPROOF

SWITCHES

FOR HAZARDOUS LOCATIONS

NOW AVAILABLE FROM **ESCO**

ESCO Type P Rotary Snap Switches, with their wide variety of rotor and contact combinations and unlimited possibilities for controlling complicated electrical circuits, are now available in explosion-proof cases. Installation is made convenient by use of standard conduit connection — ¾" for Type 10H and 1" for Type 30H.

FEATURES

- Explosion-proof
- Vapor-tight
- Standard conduit connections
- Base and panel mounting
- Weatherproof
- Dust-tight
- Aluminum housing screws on cast iron base

Cat. No.	Maximum Circuit Capacity	Mounting	Maximum Depth	Amperes	Volts
10H-I-S 10H-I-D	4PST or DPDT 8PST or 4PDT	Surface Surface	5¼"* 6" *	10	125 a-c
30H-I-S 30H-I-D	4PST or DPDT 8PST or 4PDT	Surface Surface	7¼"* 9½"*	30	500 a-c 250 d-c
30H-II-S 30H-II-D	4PST or DPDT 8PST or 4PDT	Panel Panel	6¾"** 9" **	30	500 a-c 250 d-c

*Overall including knob. **Back of panel.

BASE AND MOUNTING DIMENSIONS		
Type	Dia.	Mounting Specifications
10H	3¾"	Two lugs — 5/16" clearance holes 4½" on center
30H	6"	Four holes tapped 5/16-18 on 3" x 3" centers

WRITE FOR BULLETIN

ELECTRO SWITCH
CORPORATION
193 BROAD ST., WEYMOUTH 88, MASS.

ELECTRICAL WIRING

for

Motor Driven Machines

This 16-page article provides invaluable, fundamental information on power and control wiring details: design factors and installation requirements for efficient machine performance, trouble-free operation, and attractive appearance.

Written expressly to serve as reference material for design engineers, the text is clear and concise. Helpful photographs, diagrams, and schematic drawings supplement the text.

A few reprints of this article are available in booklet form at 25¢ each. Write to Reader Service Department.

•

PRODUCT ENGINEERING
330 W. 42ND STREET
NEW YORK 18, N. Y.

HURRICANE!

How violent? Where heading? How fast?

Hurricane warnings that save so many lives on land and sea—where do they come from? From seismograph recorders, perhaps better known for their earthquake-locating power. These sensitive instruments, stationed all over the country and on Atlantic and Pacific island outposts, locate and plot the minute-by-minute movement of violent atmospheric disturbances . . . and pen the vital data on tape.

The heart of each of these life-savers is a Telechron Timing Motor . . . *instantly, constantly synchronous.* No other motor could be trusted with the tremendous responsibility of feeding facts to the scientists who dedicate their time and talent to this most important work.

Have you a timing problem?

What variable factors do you want to control or record with split-second accuracy? The chances are that the correct application of a standard Telechron Motor is the answer to your problem. A Telechron Application Engineer can quickly tell you. Consult him early in your planning and save time and trouble. In the meanwhile, fill in and mail the coupon below today for up-to-the-minute facts about Telechron Synchronous Motors.

Telechron®

ALL TELECHRON TIMING MOTORS ARE

INSTANTLY . . . CONSTANTLY SYNCHRONOUS

Telechron Inc. A General Electric Affiliate
10 Union Street
Ashland, Massachusetts

Please send me information on Telechron Synchronous Motors (maximum torque: 2 pound inches at 1 rpm). My possible application is:

- ☐ Instruments
- ☐ Timers
- ☐ Electric Appliances
- ☐ Cost Recorders
- ☐ Advertising, display items
- ☐ Juke Boxes
- ☐ Air Cond. & Heat'g Controls
- ☐ Communications Equipment

Other (please fill in)

- ☐ _____
- ☐ _____
- ☐ _____

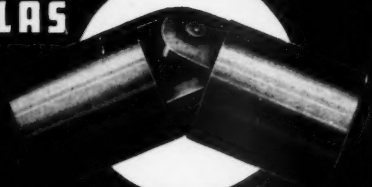
NAME_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

ATLAS



UNIVERSAL JOINTS

STRENGTH PLUS ECONOMY

Stubby jaws, heat treated alloy steel and oversized bearings guarantee maximum strength and extremely long life. Low original cost plus negligible replacements produce a saving on every application. Large grease reservoir in center block 1½" size and larger. For full details write Dept. A

GRAY & PRIOR

Makers of Atlas and Vulcan Universal Joints

THE GRAY & PRIOR MACHINE CO., HARTFORD 5, CONN.

In the West: Link Belt Co., Los Angeles, San Francisco, Portland, Seattle, Oakland, Spokane

"COMMERCIAL"

OBROUND HEADS

For oil burner tanks

275 gallons capacity

"Commercial" obround heads are formed cold in dies; each head of the same size and style fits exactly

Surfaces are smooth and flanges free from wrinkles

"Commercial" obround heads can be furnished in double dished, parabolic, flanged and dished, flat flanged and in three different sizes.

Pipe support lugs also available.

THE COMMERCIAL SHEARING AND STAMPING COMPANY.

YOUNGSTOWN 1, OHIO U.S.A.

BRONZE • CHROME ALLOY • STAINLESS STEEL • K-MONEL • MONEL • COPPER • GLASS • PLASTICS • ALUMINUM • DRILLED BALLS

Hartford

PRECISION BALLS

Precision balls made for your job. In many materials. Send your specifications to our Engineering Department. Their recommendations will be forwarded to you promptly.

THE HARTFORD STEEL BALL CO.

HARTFORD, CONN.

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2IMS48

SPECIFY

alliance motors

for

Small Load Jobs!

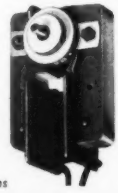
Fans	Toys
Business Machines	Vending Machines
Controls	Radio & television tuning
Heating Appliances	Other appliances
Turntables	

Mass production of small motors for *mass* markets at low cost—that's the job at Alliance!

Alliance motors rated from less than 1/400 h.p. on up to 1/25 h.p. are made semi-open, and fully enclosed. Some are uni-directional and others are reversible. Motors are designed for both continuous and intermittent duty loads. Covering a wide range of standard AC voltages and frequencies, Alliance offers motors of varied types with operating characteristics to fit the specific needs of small loads. Individual changes in design are available where quantity warrants.

Check these advantages!

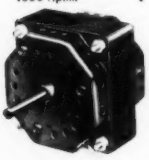
- Low operating cost
- Low induced hum
- Low magnetic field
- Low first cost
- Cool running—quiet
- Flexible power range
- Slower controlled speeds
- Long life

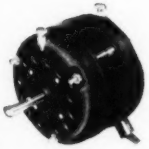


Write for catalog and specifications

MODEL B

4-pole shaded pole motor. Approx. 1/30 h.p. 1550 r.p.m.





MODEL A

6-pole shaded pole motor. Approx. 1/30 h.p. 500 to 1050 r.p.m.

MODEL MS

2-pole shaded pole motor — full load h.p. .0021. Full load 2800 r.p.m.

ALLIANCE MANUFACTURING COMPANY • ALLIANCE, OHIO

Export Department: 401 Broadway, New York 13, N. Y., U. S. A.

TRY this Low Cost Pump for:

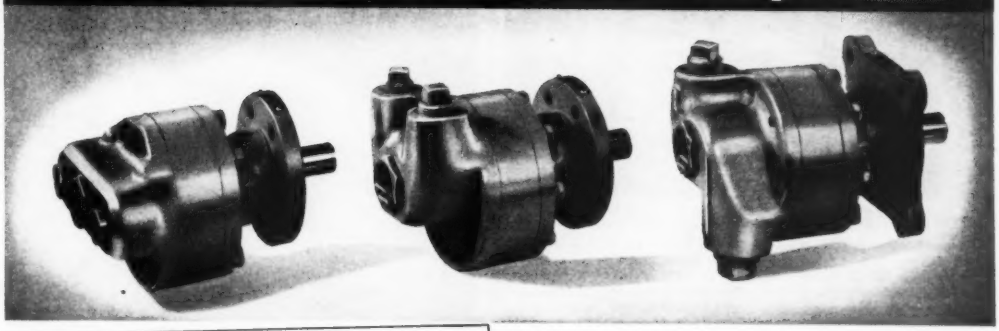


Illustration shows the Model 5W with porting arrangements that can be furnished. Two styles of flange mountings are shown and foot mounting bracket can be furnished (extra) if desired.

QUIET, EFFICIENT OPERATION

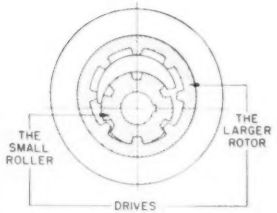
The Sundstrand Model 5W pump incorporates the outstanding Rota-Roll principle and pumping members which are responsible for the quiet, efficient operation in over 1,500,000 pumps. Because the basic elements are common to many other Sundstrand hydraulic units, the cost of the 5W pump is low.

Try it on the following:

Materials handling equipment, agricultural machinery, industrial heating units, lift trucks, and similar equipment can be improved through the application of the Model 5W.

THESE FEATURES INSURE ITS QUIET, EFFICIENT PERFORMANCE

Rota Roll Principle of pumping members promotes quiet operation, longer life because smaller roller is keyed to shaft and drives outer member at a speed 25% lower than motor speed.



Smooth, Uniform Flow at all Pressures because rotating roller and rotor are self-emptying, eliminating turbulence and other interference with smooth, uniform flow of oil.

Small and Compact (see illustration) will lend itself to and improve your product appearance.

High Overall Efficiency at maximum continuous duty pressure.

3 Standard Porting Arrangements. Another desirable feature of the Model 5W is its versatility in mounting and porting. The illustration above shows porting arrangements that can be furnished, making the pump adaptable to practically any piping requirements.

Available in 7 Sizes Ranging from 4 to 10 GPM. The Model 5W is furnished in 7 different capacities ranging from 4 to 10 GPM at 1200 RPM. Capacities are determined by width of pumping members, and all 7 sizes of pumps with the same combination of porting and mounting arrangement have the same basic dimensions excepting overall length. The pump is suitable for 1200 PSI service and operation at speeds up to 1800 RPM.

Low Cost because the basic elements of this efficient constant volume pump are common to many other Sundstrand hydraulic units. Sheave or pulley type drive pump can also be furnished.

FREE Additional Data

will be furnished on request. Write today, ask for P40.

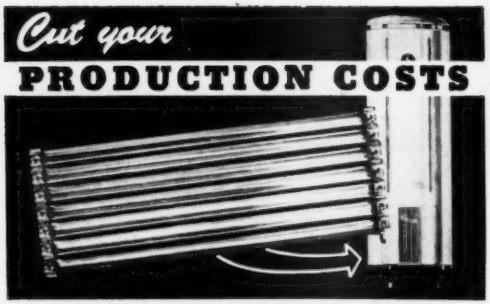
SUNDSTRAND MACHINE TOOL CO. ROCKFORD, ILLINOIS, U.S.A.

SUNDSTRAND HYDRAULIC DIVISION

256 ELEVENTH STREET • ROCKFORD, ILLINOIS

FUEL UNITS • HYDRAULIC PUMPS • TRANSMISSIONS • FLUID MOTORS • VALVES and CONTROLS

Cut your
PRODUCTION COSTS



with GREENE MOULDING ASSEMBLIES

Where your product design calls for grille work, louvres, decorative trim, etc., that mean plated castings or one-piece stampings, check the savings Greene UNI • FORM • Moulding Assemblies can make for you. Made by the economical Greene process of assembling low-cost mouldings and stampings, you'll find UNI • FORM Moulding Assemblies give you . . .

- Lower cost per unit
- Equal or greater strength
- Reduced weight
- Economical repair or replacement
- High quality appearance

ASK FOR IT!

If you use production quantities of parts that can be made by this cost saving process, please send us details, blue prints and quantities required. No obligation on quotations, of course.

Free Catalog of decorative moulding shapes.

• Trademark

Greene Manufacturing Company Inc.
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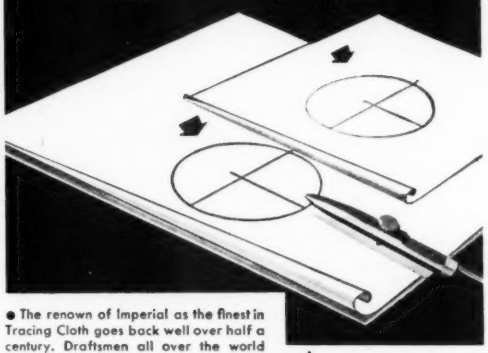

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who advertise

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★

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★

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FIVE ZINC BASE DIE CASTINGS

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These precision parts incorporate unusual shapes, intricate sections, dimensional accuracy and enough rugged strength to stand up under the thoughtless abuse often encountered in domestic kitchens.

SALES APPEAL, ECONOMY

The smooth, satiny outer surfaces of frame, handle and lever castings make time-consuming finishing operations unnecessary; only the final dress coating of enamel need be applied for an eye-appealing product. Sales appeal is packed, too, in the public's acceptance of metal for strength and precision. It's zinc for these qualities *plus* durability.

FOR INTERESTING NEW PRODUCTS, NEW INTEREST IN OLD PRODUCTS, INVESTIGATE ZINC BASE DIE CASTINGS

ANACONDA SALES COMPANY

25 BROADWAY, NEW YORK 4, N. Y.

Subsidiary of Anaconda Copper Mining Co.

COPPER · ZINC · LEAD · SILVER · CADMIUM · BISMUTH · ARSENIC

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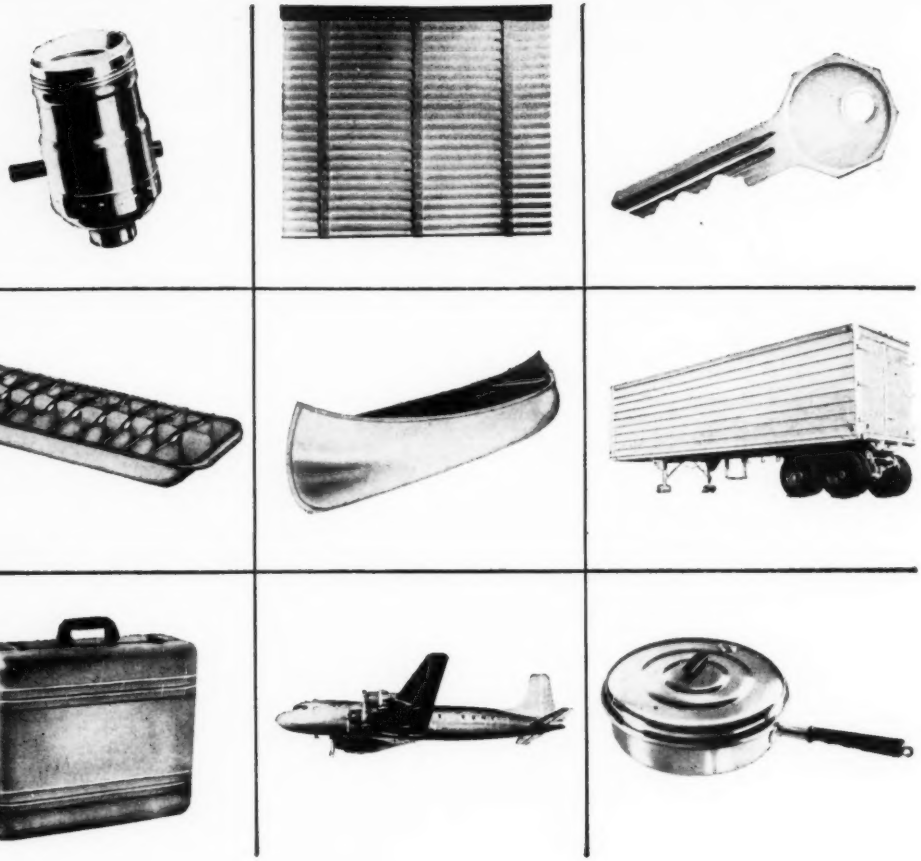

Aluminum does them all—but . . .

Naturally, you don't make pots and airplanes with the same alloy.

To manufacture the products illustrated above, a *variety* of alloys and tempers of aluminum are required—each suited to the specific requirements of the job.

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Increased strength . . . reduced weight . . . improved finish . . . greater durability.

Furthermore, by making a change in alloy or temper you may be able to *reduce your manufacturing costs* through:

Lower material cost . . . fewer fabricating steps . . . lower rejection rate . . . lower finishing costs.

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Permanente Metals

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Kaiser Aluminum

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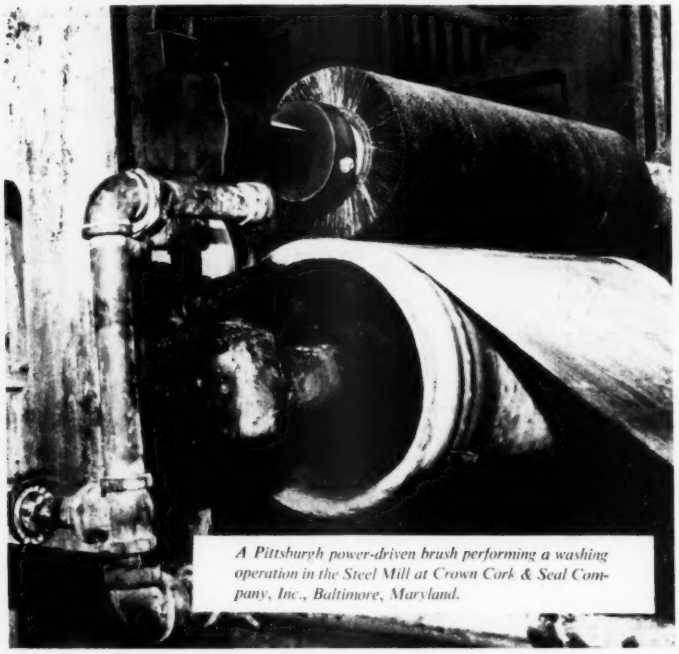
"PITTSBURGH" *Power Driven* BRUSHES



A Pittsburgh power-driven brush performing a washing operation in the Steel Mill at Crown Cork & Seal Company, Inc., Baltimore, Maryland.

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- STEEL
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- RUBBER
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- SHOE MANUFACTURING and REPAIRING

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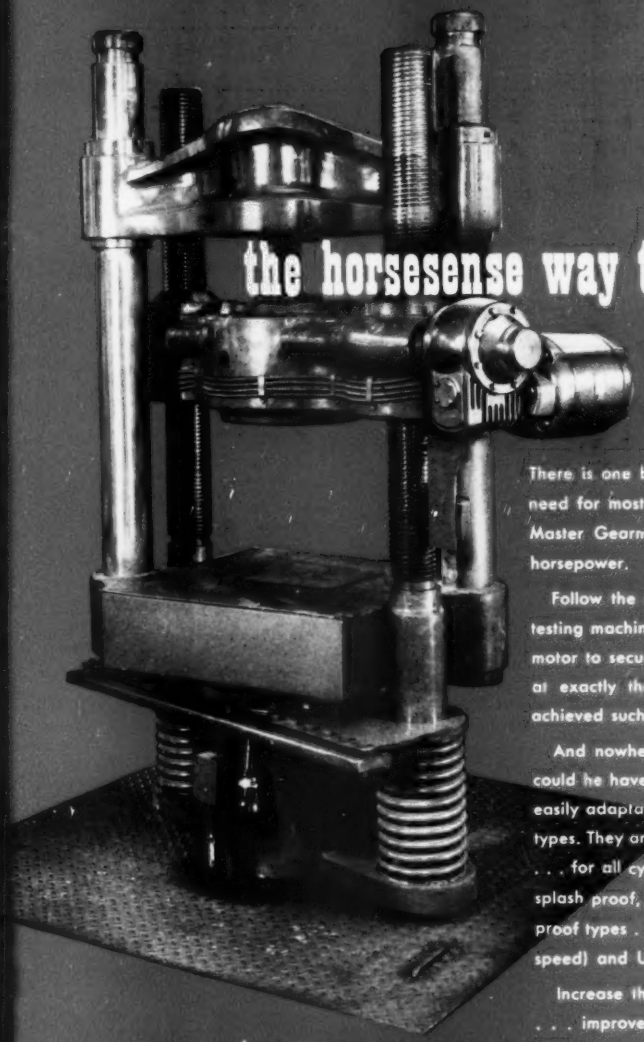

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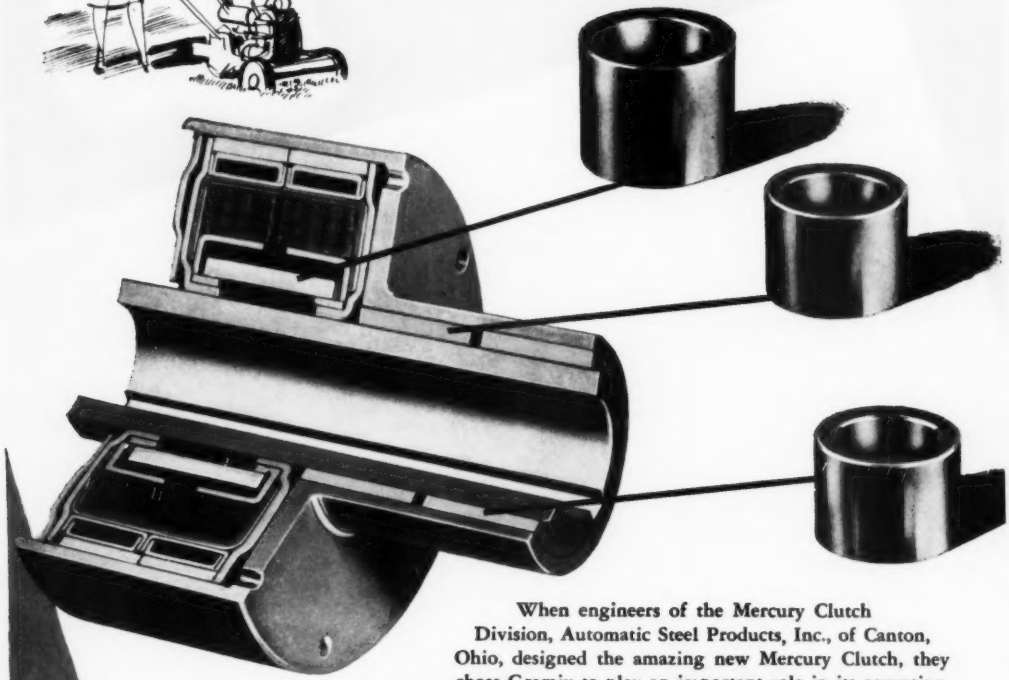
GRAMIX helps Mercury Clutch eliminate power transmission problems



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